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Research Report

Sixty-Five Years of Physical Therapy: Bibliometric Analysis of Research Publications From 1945 Through 2010

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Background and objective

The generation of research can be likened to the production of consumer goods, with a producer (the study authors and funders), a product (the study and publications arising from it) and consumers (those who read and cite the published study). The aim of this study was to use bibliometric indices to track changes in the producers, products and consumers of the Physical Therapy journal from 1945 through 2010.

Design

An analysis of published manuscripts (excluding letters, editorials, corrections, commentaries and book reviews) in Physical Therapy was performed using a reliable bibliometric audit tool. Articles were sampled every three months and at five-year intervals over a 65 year period. Information relating to authorship, the research methods used and citation patterns was collected. Data were analysed descriptively.

Results

There have been substantial shifts in the nature of research published over the last 65 years in Physical Therapy. In 1945, the typical paper was anecdotal and authored by 1.4 American authors (working in hospitals), and consisted of 4 pages and 4 references. In 2010, the typical paper used a cross-sectional survey or randomized controlled trial design, with 4.6 multinational authors (working in universities), consisting of 12 pages and 49 references.
Conclusions

The changes seen in the research published in Physical Therapy mirror the shifts that have occurred in other industries, those of increasing quantification, standardisation, collaboration, and internationalisation. These trends are likely to continue in the future.
The journal of the American Physical Therapy Association, *Physical Therapy*, commenced in 1921 with the objective of promoting contact between physicians and aides. The journal has moved from being a vehicle for communication between professionals to being a “leading international journal for research in physical therapy and related fields.” The production of research can be conceptualised in the same way as the production of other goods. There is a producer (individuals or teams of researchers), a product (the subsequent documentation, presentations and peer reviewed articles arising from the study), and consumers (anyone who reads or cites the documentation). The research process leaves a bibliometric paper trail which can be used to characterise the production chain. Through bibliometric sources we can gain information about the producers (for example, the number and country of origin of the authors and their affiliations, presence and sources of funding), the product (such as research design and topic, sample size and gender mix) and finally aspects of research consumption (for example citation indices can quantify the uptake of the research).

Bibliometric analysis of this sort can be used to describe the current state of research, but perhaps more interestingly, to chart historical changes in clinical practice and research norms. Historical analysis of a research series, such as articles published in journals affiliated with professions such as Physical Therapy reflect the maturation of the profession, the current state of research and some likely future trends. Because the production of research is subject to much the same social and economic pressures as other types of production (such as market globalisation, quality control, standardisation and regulation, and the impact of new information technologies), we might expect to see in these historical analyses the same trends as we see in other areas of the economy (for example, greater production volume, increasing competition, internationalisation, and agglomeration of small production units into larger groups).
Several bibliometric analyses have been conducted in physical therapy. While early bibliometric studies tended to focus solely on research consumption (citations) more recent research has aimed to describe the research product (such as research topic and content, methodology, purpose and rigor, quality of evidence, or research producers). A comprehensive bibliometric assessment of the research product (research designs, topics and sample populations) was conducted in a very recent study by Coronado et al. in a sample of topical reviews, research and case reports published in Physical Therapy between 1980 and 2009. However to date, no bibliometric study has been identified which has charted change in all three components of the research production process (producers, product, and consumption) over more than a thirty year period and in relation to physical therapy.

For the purpose of this study, “bibliometrics” was defined as any set of research evaluation methods that were based on either citation or content analyses. The aim of this study was to use traditional (e.g. citation index) and novel (e.g. evidence, quantitative and collaboration indices) bibliometric indices to track changes in the producers, products and consumption of research published in Physical Therapy from 1945 through 2010. This journal was selected as it has a long lineage relative to other physical therapy journals (first published in 1921), it is considered a core journal in the physical therapy profession and has been consistently highly ranked in this area in Web of Science rankings. By describing the publication patterns of Physical Therapy over the last sixty-five years in this study, inferences may be made about the evolution of the physical therapy profession.
Method

Every published manuscript (including qualitative studies) in *Physical Therapy*, with the exclusion of letters, editorials, corrections, commentaries and book reviews, was examined at three-monthly intervals (March, June, September, December) and every five years from 1945 [first publication year available to researchers (including print and electronic versions)] through 2010 [most recent full year of data available in the sampling frame]. The sampling timeframes were selected as a compromise between yielding sensitive bibliometric data and making data collection manageable. Similar selective sampling methods have been used in other bibliometric studies. Supplemental volumes were not included in the analyses. Articles were reviewed using a bibliometric analysis tool (BAT) (Appendix 1). This tool consists of 30 items which evaluate the characteristics of:

- the *producers* [numbers of authors and affiliations and their country of origin; presence and sources of funding; type of affiliation (hospitals, health services and private practices were classified as health providers, university and research institute affiliations as education and research sectors)];

- the *products*, i.e. the study design used (criteria included in Appendix 2); research topic (keywords); sample size and gender; mean sample age; the statistical approach (descriptive or inferential) used; and the format of the article (number of pages, tables, figures, references)]; and

- research *consumption* [times cited, as reported by *Web of Science* (viewed 17 August 2011), available only from 1983 onwards]. *Web of Science* was selected as the primary database for these data as it is has been suggested that *Web of Science* retrieves a greater proportion of citations from articles than Scopus, and is more accurate than Google Scholar.
While each of the 30 items can be considered separately, three indices derived from the items permit synthesis of data concerning characteristics of research design (Evidence Index), research approach (Quantitative Index) and research collaboration (Collaboration Index):

- **Evidence Index**: This index is an indicator of the study design, with higher values being allocated to higher study designs. Six points are allocated for a systematic review, 5 for a randomised controlled trial (RCT), 4 for a non-randomised controlled trial, 3 for a cohort study, 2 for a case control study, 1 for cross-sectional, pre-post, methodological and case studies, and 0 to expert opinion, narrative reviews and anecdotal evidence (Appendix 2). For studies using multiple research designs, they were scored according to the ‘higher’ level of evidence used.

Qualitative studies were allocated to a separate ‘qualitative’ research design category and did not receive an Evidence Index score.

- **Quantitative Index**: This index is a measure of the degree of quantitation in a study. It is calculated as the sum of the number of figures and tables per page plus one point if the study uses inferential (as opposed to purely descriptive) statistics.

- **Collaborative Index**: This index quantifies the degree of collaboration involved in the study. It is calculated as the number of authors plus the number of institutions represented by the authors plus the number of different countries those institutions are located in.

The articles were read in full and evaluated by a single researcher (LM). Bibliometric data were extracted “verbatim” where appropriate. The inter-rater reliability of the BAT has been previously demonstrated and confirmed in this study through auditing a random sample of 10 articles on two occasions three months apart (numerical items ICC (1, 1) 0.99 to 1.0, and categorical items (Kappa 0.94 to 1.00). A sample of research articles (n=28) published in Australian nursing and allied-health professional journals was used to establish the concurrent validity of the BAT. The corresponding authors of these 28 research articles were contacted to complete the BAT and verify bibliometric data extracted by one of the...
authors (LW) of the current study. Agreement was good to excellent (Kappa 0.87 to 1.0) and substantial (Concordance correlation coefficient 0.92 to 0.99) for categorical bibliometric data.

All data were analysed descriptively and grouped according to whether they related to the research producers, products or consumption. Means and frequencies of bibliometric data were derived from all articles audited in four issues across each year and based on only those articles for which the bibliometric items were relevant. For example, sample size was recorded for all studies where appropriate (excluding anecdotal evidence, expert committee, and narrative reviews). The frequency and types of keywords published in articles over the most recent 30 years (1980 through 2010) of the study period were recorded verbatim and used to represent and describe change in research topic. Each keyword was categorised under one of the eighteen American Physical Therapy Association (APTA) special interest ‘sections’ depending on the nature of the word itself and the sample or focus of the article using the keywords. The APTA ‘sections’ were then separated into those that related to the clinical aspects of physical therapy (e.g. aquatic, acute care, cardiovascular and pulmonary, clinical electrotherapy and wound management, hand rehabilitation, home health, neurology, oncology, orthopaedic, private practice, sports); professional issues (e.g. education, federal, health policy and administration, research); and populations (e.g. geriatrics, pediatrics, women’s health).

Results

A total of 337 published manuscripts in 56 issues of Physical Therapy were audited (Table 1). The number of published manuscripts included in 4 issues each year in Physical Therapy more than doubled (n=14 in 1945, n=37 in 2010) over the study period.
**Producers**

Over the study period, there was a trend towards larger research teams with greater international representation and this was reflected in the change in research article scores for the Collaboration Index (CI) (Figure 1). From *Physical Therapy*’s inception the Collaborative Index rose until the year 2000 where scores for manuscripts published in the last decade more than doubled (Collaborative Index mean score 4.1 in 2000, 8.5 in 2010).

The mean number of authors per paper increased three-fold (1.4 authors in 1945, 4.6 in 2010), and their mean number of affiliations more than doubled (1 affiliation in 1945, 2.7 in 2010). All studies published in 1945 (and also between 1950 and 1960 inclusive) were authored from within the same country (mean of 1.0 different author countries per article) whereas 16.2% of 2010 (n=6) articles were authored from multinational teams (mean 1.2 author countries per article). In 1945, the proportion of authors whose affiliations were based outside of North America was 5.3% (n=1, United Kingdom only), and rose by 2010 to 39.5% (n=68). In 2010, the location of international author affiliations were Canada (n=28, 41.2% of all international affiliations), Australia (n=12, 17.7%), Taiwan (n=11, 16.2%), Belgium (n=7, 10.3%), the Netherlands (n=6, 8.8%), and Chile and Israel (n=2, 2.9% each). The historical trend in type of author affiliation (health providers versus education and research sectors) is shown in Figure 2 (refer to trendline). Over the study period, the decrease in the proportion of ‘health provider’ author affiliations (n=7, 77.8% of all author affiliations in 1945; n=31, 30.4% in 2010) was mirrored by an increase in those from the education and research sector.
(n=2, 22.2% of all author affiliations in 1945; n=71, 69.6% in 2010). No research studies in 1945 reported receiving funding, however 81.1% (n=30) of those published in 2010 were funded.

**Products**

There were changes in the type of research designs (Figure 3, refer to trend line) and greater use of inferential statistical analyses and tables and figures for reporting data (reflected by the Quantitative index) over the study period (Figure 1). ‘Higher’ research designs (as reflected in higher Evidence Index scores) were used in included studies from 1945 through 2010 (Table 2). Specifically, the use of cross-sectional research designs and randomized controlled trials increased [both 0% of all research articles in 1945, both 24.3% (n=9) in 2010], with growth also seen in the use of case studies ([0% in 1945, 13.5% (n=5) in 2010)] and uncontrolled experiments ([0% in 1945, 10.8% (n=4) in 2010]). Anecdotal research articles were the sole source of evidence in 1945 (n=14) but had disappeared from the journal by the end of the study period (Figure 3). By 2010, other study designs [systematic reviews and cohort studies (both 8.1% of all research articles, n=3), and non-randomized controlled trials (5.4%, n=2)] had risen in prevalence. Over the study period, few published manuscripts (n=1 published in 1985, n=1 in 1995, n=2 in 2010) were identified that employed qualitative methodology. In this sample of published manuscripts audited, no methodological studies were identified.

Table 3 presents the proportion of keywords for 1980 through 2010 according to the APTA sections. The use of keywords grouped in ‘research’ (8.1% of all keywords in 1980, 24.9% in 2010) increased the most over the study period. There was a reduction in the use of keywords grouped in ‘acute care’ (16.2% of all keywords in 1980, 1.7% in 2010), ‘clinical electrotherapy and wound management’ (9.1% in 1980 to 0.7% in 2010)
and ‘sports physical therapy’ (20.2% in 1980, 2.1% in 2010). No studies were identified in this sample that used keywords relating to ‘aquatic physical therapy’, ‘hand rehabilitation’, ‘oncology’ and ‘private practice’ at any time during the study period.

In reporting sample size data, median values were chosen as mean values were skewed by a few studies with large sample sizes. Median sample size was 52 in 1950 (based on only 2 studies in which sample size was relevant) and 57 in 2010 (based on 35 studies for which sample size data was relevant). Mean sample age (in relevant studies) increased from (30 years in studies in 1950 to 41 years in 2010). The percentage of articles recruiting both male and female participants increased over the study period (0% of all relevant studies in 1950; n=30, 88.2% in 2010). These data are summarised in Figure 4 (refer to trendline). The median sample sizes for the years 1965 and 1975 were greater than other values. In 1965 this pattern was attributable to a large cross-sectional study (sample size n=300) and in 1975 to large cross-sectional (n=327) and cohort (n=285) studies.

**Consumption**

The mean number of citations to published manuscripts in each year for which data were available in *Web of Science* (1985, 1990, 1995, 2000, 2005, 2010) were calculated. Over the study period, more recent research articles in *Physical Therapy* (in the 1990s and 2000s, with the exception of 2010) tended to receive more citations (than those in the mid 1980s) despite being published for less time (Figure 5).

**Discussion**
This is the first study to report historical trends of published manuscripts in the journal of *Physical Therapy* over a 65 year time frame. Several bibliometric studies have been conducted in physical therapy, however no study was identified that charted change in all three components of the research production process (producers, product, consumption) over more than a decade of publications and in relation to physical therapy. From 1945 through 2010, there were a number of changes in the characteristics of research producers, products and consumption in *Physical Therapy*.

The trends in published manuscripts in *Physical Therapy* are clear; over the course of 65 years, more research (14 studies in 1945, 37 in 2010) was published by larger research concentrations from different affiliations (Collaborative Index 3.4 in 1945, 8.5 in 2010), using higher research designs (Evidence Index 0 in 1945, 2.8 in 2010), and greater quantitation (Quantitative Index 0.38 in 1945, 1.3 in 2010) (Figure 1). Several of the findings in the current study are similar to those reported by Coronado et al. despite the authors using different sampling frames (all journal issues published between 1980 and 2009 inclusive) and bibliometric measures (content analyses). For example, in both studies there was a trend towards the use of higher research designs over the study period however the overall proportions of systematic reviews in the current study (8.1% of all published manuscripts in 2010) remained relatively low compared with other research designs used (Table 1). In addition, both studies found most research published in *Physical Therapy* was conducted by authors affiliated with universities.

In the current study, the move from ‘cottage’ (small scale individual producers) to ‘industrial’ (large scale highly organized producers) models of research production has also been reported in other health related bibliometric literature in terms of research volume and the number of authors...
involved\textsuperscript{3, 40}, the location of international contributors\textsuperscript{41-43}, socio-demographic determinants\textsuperscript{44, 45}, and the sophistication of research methods used and data reporting\textsuperscript{20}.

These findings are not surprising given the conceptual and technological advances that have occurred over the study period making data collection and analysis process more sophisticated and dissemination easier. Collaboration between different authors, institutions and countries has been facilitated by cheaper international travel, the widespread use of electronic media, a larger critical mass of researchers, and fierce competition in the research market for employment and funding opportunities. The rise of the concept ‘evidence based practice’ (EBP) in the early 1990s (marked by the founding of the Cochrane Collaboration in 1993)\textsuperscript{46} has helped facilitate the evolution of research methods towards higher designs necessary to underpin treatment decision making which subsequently informs the provision of effective and resource efficient health services. Quantitative data analyses have been facilitated by advances in information technology, improved statistical software packages and the development of standards for reporting research, such as CONSORT and PRISMA guidelines\textsuperscript{47, 48}. As CONSORT and PRISMA guidelines require detailed reporting of individual participant and study data (including recommending the use of tables and figures), this may in part account for the greater quantitation seen in articles published in Physical Therapy over time. Physical Therapy requires submitting authors to follow these statements and also limits topical or narrative reviews to clinical perspectives and invited commentaries. These and other journal policies may encourage the selective submittal of articles using higher research designs to Physical Therapy (compared with other physical therapy journals).
In the current study, the Evidence Index and Quantitative Index rose steadily but relatively modestly over the study period. The majority of the rise in the Evidence Index score occurred after 1990, and the Quantitative Index after 1975 which mirror some of the key research and computer-related developments, and may assist in explaining the larger sample sizes employed in research studies published later in the study period (move towards experimental research designs, software to manage and access large data sets) (Figure 4). By contrast, the Collaborative Index in this study more than doubled and increased sharply after 2000 (Figure 1). There are several plausible explanations for the publication patterns presented by Physical Therapy. The journal’s current mission statement is explicit in aiming to ‘engage and inspire an international readership.’ Therefore it is possible that research with an international authorship has been increasingly submitted for consideration by Physical Therapy. As an alternate hypothesis, collaboration among more authors and among different institutions and countries may have actually grown due to factors such as the adoption in 1995 of declarations of principle and position statements by regions in the World Confederation for Physical Therapy (WCPT)\textsuperscript{49}. The most common locations of international collaborating authors of research over the study period but particularly in 2010 (Canada, Australia, Taiwan, and Western Europe) support this idea given these countries (and others in which international authors who published in Physical Therapy resided) are well represented in the WCPT. The predominance of collaborating authors from highly industrialized and developed countries could reflect increased competition in all markets, and especially the research market. However, it should be acknowledged the rise of the Collaborative Index may simply reflect population growth, and specifically growth in the size of the overall health and physical therapy workforce. This would mean there would be more opportunities for collaboration.
Over the study period, there was a greater proportion of research published in the journal by authors in the research sector (universities and research institutes) than those involved in health service provision (hospitals, health services and private practice). This trend was also reflected in the shifts seen in the topics of research articles (keyword analyses); with growth in the use of keywords reflecting ‘research’ as opposed to the decline in use of keywords relating to clinical areas of physical therapy (such as ‘acute care’, ‘clinical electrotherapy and wound management’, and ‘sports’). Keyword analyses were conducted only over the most recent ‘generation’ of the study period for which keywords were available (1980 –2010). The first two APTA sections (‘Education’ and ‘Private Practice’) were developed during the 1940s with many others (‘neurology’ section commenced in 1972, ‘paediatrics’ and ‘sports physical therapy’ in 1973, ‘orthopaedics’ in 1974, ‘aquatic physical therapy’ in around 1992) established in the years thereafter. The evolving research focus of Physical Therapy has also been exemplified by the recent publication of various editorials. Research being conducted predominantly in the area of and by authors in the research sector is most probably due to two important factors. First, research requires skills and infrastructure that health services may be unable to provide. These resource discrepancies may have become more pronounced as research has grown in its complexity and the scale on which it is conducted. Secondly, a changing workforce demographic may be at play. A greater number of research-skilled physical therapists and/or physical therapists who are skilled research consumers now exist. In a demographic profile of physical therapist members of the APTA, the proportion of respondents indicating the highest degree earned was a doctorate (either Doctor of Physical Therapy (DPT) or other doctorate) almost doubled over the last five years (21.4% of respondents in 2005, 41.2% in 2010). This may be due to the increased number of professional level Doctor of Physical Therapy (DPT) programs on offer in the United States. If the increased proportion of physical therapists holding doctoral qualifications is predominantly due to graduates from entry level DPT programs rather than graduate PhD programs (the proportion of APTA members with a
PhD as their highest earned degree remained stable, 6.2% in 2005, 6.7% in 2010\textsuperscript{55}, it seems unlikely that this would explain the growth in authors currently working within the academic setting. Physical therapy education programs have shifted from hospitals (health provider settings) to universities and research institutes (research sector) with tenure. This, combined with current accreditation standards requiring core full-time faculty members to demonstrate scholarly activity through research publications, means it is probably not surprising that the bulk of research published in Physical Therapy in recent years has been conducted in the education and research sectors\textsuperscript{57}.

Research across a greater cross-section of topics was published in Physical Therapy in 2010 (keywords in n=14 APTA sections) than 1980 (n=10) (Table 3). This may be due to the emergence of newer sub-specialties within the physical therapy profession, the profile and relative membership of each ‘section’, and the opportunities for research to be published in section-specific publications rather than Physical Therapy\textsuperscript{33}. The APTA sections vary significantly from one another in terms of their year of establishment, number of special interest groups (none in the ‘federal’ section, ten in ‘sports physical therapy’), number of members (ranging from approximately 1000 members for ‘clinical electrotherapy and wound management’ to over 13,000 for ‘orthopedics’), and the nature and frequency of their associated publications (such as a semi-annual newsletter for the ‘research’ section, 2 journals for ‘sports physical therapy’). These differences may account for the publication patterns seen in this study. It is also likely that shifting economic, political and socio-demographic needs (towards research, geriatrics, older populations and those of both genders) have helped shape and govern the research that is conducted and also selected for publication. A mature profession and professional journal needs to adapt to these changes, and rather than try to be ‘all things to all people’ identify important and niche areas of research, and foster and publish these studies preferentially.
In terms of the consumption of research published in *Physical Therapy*, there appeared to be a trend towards more recent publications receiving a greater number of citations despite being published for and therefore accessible to its readership for less time (Figure 5). This suggests that research consumption is overall increasing, and the research community is particularly interested in more recent publications. Curiously, there was a sharp fall in the number of citations of articles published after 2000 in the present study, which was also noted in the ISI Web of Science Journal Citation Reports Cited Journal Graph for *Physical Therapy* in 2004 and 2005, and after 2006\textsuperscript{58}. While the reasons for this are unclear, 2005 was a period of editorial transition for *Physical Therapy* in terms of board membership and publication and review processes\textsuperscript{59}.

Bibliometric measures can be made at the research producer, product and consumption level and can provide valuable information regarding research performance. Bibliometric research is a way of describing intellectual activity and quantifying research performance over time and among different types of producers (such as different institutions and professions). Performance indicators such as these are important given there is increased competition in the research market between researchers and institutions for available resources, and an accelerated drive towards evidence-based and cost-effective health care. Bibliometric studies are useful in describing the natural history of a profession or publication, and can be used in benchmarking activities with and against other journals and disciplines or to evaluate the effectiveness of research initiatives. It is important that a profession, or a professional journal remains intrinsically ‘in tune’ with its members and readership to respond to these factors and the changing tempo of the research market. *Physical Therapy* ‘consumers’ may use the journal by citing published manuscripts or through general readership. Therefore, the total ‘consumption’ of *Physical Therapy* by APTA members may not be reflected in
traditional citation-based bibliometric indices alone. Over 50 percent of current APTA members are employed in private or health system/hospital based outpatient facilities55 who are more likely to use research findings published in Physical Therapy in their clinical practice rather than through citation. Therefore, the degree of ‘harmony’ between a professional journal and its target demographic (readership and members) may be able to be captured more completely with the use of more novel bibliometric indices that can describe the research designs used, populations and topics studied, the productivity of various research teams, and access and download rates of published manuscripts. It appears that over the last sixty-five years, Physical Therapy has been in concert with many of these factors and has endeavoured to remain true to the goals of facilitating contact between researchers and countries. It is likely that these publication trends in Physical Therapy, and in general, will continue and escalate in the future.

**Limitations**

There are a number of limitations to consider with this study. The sampling frame chosen for sourcing articles to audit (three monthly and five yearly intervals) did not take into account that subtle temporal variations in the nature of research published may exist over the course of one publication year. Physical Therapy publishes occasional ‘special issues’ and over the study period these occurred in February (1960), April (1965), May (1965), July (2000), August (2000), September (1975, 2000, 2005), November (1950, 1955, 1960, 1975) and December (1950, 1980, 1985, 1990, 2010) issues. While it does not appear these ‘special issues’ are consistently and systematically published at particular times of the year, a large proportion were captured in our sampling frame (September and December issues). The ‘special issues’ included in our sample focussed on specific research topics rather than research methodologies (‘circulation’ in 1950, ‘the hip’ in 1975, ‘the knee’ in 1980,
‘cardiac rehabilitation’ in 1985, ‘movement science’ in 1990, ‘spinal cord series’ in 2000, ‘Ottawa panel evidence-based clinical practice guidelines for therapeutic exercise and manual therapy in the management of osteoarthritis’ in 2005, and ‘pediatrics’ in 2010). As our intent was to describe historical trends in the research published in Physical Therapy, our sampling frame is likely to have captured a representative sample of articles for this purpose. The data presented in this study are a function of the sampling procedures and specific methodologies employed. These include the availability of the journal (post 1945 publications only) and the reliability and validity of the classification and categorization systems used (such as the Web of Science database for citation data, and the scoring criteria developed for this study). However, data for the entire sample were extracted using consistent methods (allowing description of historical trends) and demonstrated acceptable reliability and validity on psychometric testing. Included articles were not assessed for methodological bias therefore historical trends in the quality of research published in Physical Therapy over time cannot be determined as a result of this study. All data were reported descriptively and no interaction effects were specifically investigated. Therefore when interpreting the results of this study, it is important to be cognisant that the reasons offered for the trends seen in the current study are hypotheses that have not been tested statistically. The findings of this study describe the historical publication patterns of the Physical Therapy journal and should not be interpreted as representing the overall research performance of the American physical therapy profession. The results of this study are specific to Physical Therapy and may not accurately represent the types of research conducted by the physical therapy profession in general, or indeed physical therapist researchers in the United States or around the world. In the future, it may be useful to perform bibliometric audits using consistent measures (contained in one audit tool) and sampling a range of physical therapy journals (such as those affiliated with professional associations from other countries) or journals related to other health professions and disciplines to help map research type and territories among journals, professions and disciplines.
Conclusion

The findings of this study demonstrate an evolving research base in physical therapy, characterised by the use of higher research designs and quantitative analyses by larger research concentrations from different countries and multiple university-based affiliations. It is likely these changes have been driven by a variety of external forces (such as the rise and emphasis on evidence based health care, and technological advancements) and intrinsic factors (such as specific journal Editorial policies, and the profile and membership of professional groups and subspecialties). It is likely these trends will continue into the future. Bibliometric analyses may be used to track and chart the development of professional journals. However, to more thoroughly understand this type of ‘professional development’, it may be useful to use bibliometric analyses that extend beyond pure ‘consumption’ (such as traditionally used citation rates) and capture information regarding research ‘products’ and their ‘producers’.
Ms Wiles, Ms Matricciani, and Dr Olds provided concept/idea/research design. All authors provided writing and data analysis. Ms Wiles and Ms Matricciani provided data collection. Ms Wiles provided project management.

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References


   http://ptjournal.apta.org/site/misc/about.xhtml.


Table 1. The number of studies of different research designs published in Physical Therapy over the study period (n=337)*.

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* all data are from 4 issues per year
### Table 2.
Evidence index scores (mean) for included articles published in *Physical Therapy* over the study period.

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<tr>
<td>1960</td>
<td>0.56</td>
</tr>
<tr>
<td>1965</td>
<td>0.24</td>
</tr>
<tr>
<td>1970</td>
<td>0.6</td>
</tr>
<tr>
<td>1975</td>
<td>0.31</td>
</tr>
<tr>
<td>1980</td>
<td>0.38</td>
</tr>
<tr>
<td>1985</td>
<td>0.73</td>
</tr>
<tr>
<td>1990</td>
<td>0.63</td>
</tr>
<tr>
<td>1995</td>
<td>1.16</td>
</tr>
<tr>
<td>2000</td>
<td>1.27</td>
</tr>
<tr>
<td>2005</td>
<td>1.79</td>
</tr>
<tr>
<td>2010</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Table 3.
Keyword distribution according to the different American Physical Therapy Association (APTA) sections for articles published in *Physical Therapy* for the individual years 1980 through 2010.

<table>
<thead>
<tr>
<th>APTA section</th>
<th>Percentage of all keywords used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
</tr>
<tr>
<td>Acute care</td>
<td>16.2</td>
</tr>
<tr>
<td>Aquatic physical therapy</td>
<td>0.0</td>
</tr>
<tr>
<td>Cardiovascular and pulmonary therapy</td>
<td>0.0</td>
</tr>
<tr>
<td>Clinical electrotherapy and wound management</td>
<td>9.1</td>
</tr>
<tr>
<td>Hand rehabilitation</td>
<td>0.0</td>
</tr>
<tr>
<td>Home health</td>
<td>0.0</td>
</tr>
<tr>
<td>Neurology</td>
<td>6.1</td>
</tr>
<tr>
<td>Oncology</td>
<td>0.0</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>12.1</td>
</tr>
<tr>
<td>Private practice</td>
<td>0.0</td>
</tr>
<tr>
<td>Sports physical therapy</td>
<td>20.2</td>
</tr>
<tr>
<td><strong>Professional</strong></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>3.0</td>
</tr>
<tr>
<td>Federal</td>
<td>0.0</td>
</tr>
<tr>
<td>Health policy and administration</td>
<td>11.0</td>
</tr>
<tr>
<td>Research</td>
<td>8.1</td>
</tr>
<tr>
<td>Populations</td>
<td>8.1</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Geriatrics</td>
<td>6.1</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Figure 1.
Longitudinal trends in the Collaboration Index (left ordinate, filled dots), and Quantitative Index (right ordinate, empty dots) for published manuscripts over the study period.

Figure 2.
Longitudinal trends in the proportion of author affiliations in the education/research sector (filled dots, solid lines) and health providers (empty dots, dotted lines) for published manuscripts over the study period.

Figure 3.
Longitudinal trends in the proportion of different research designs used over the study period. Experimental designs including RCT, non-RCT, cohort, case control and uncontrolled experiments (filled black dots, dashed line), cross-sectional surveys (empty dots, dotted line), and anecdotal evidence (filled grey dots, solid line).

Figure 4.
Longitudinal change in (a) sample size (median), (b) sample age and (c) percentage of studies sampling both male and female participants.
Figure 5.

Longitudinal change in the mean number of times research articles published in *Physical Therapy* were cited.
Figure 1. Longitudinal trends in the Collaboration Index (left ordinate, filled dots), and Quantitative Index (right ordinate, empty dots) for published manuscripts over the study period.
in 1965 and 1980, there was an equal split between the two types of author affiliations (50% of author affiliations were in the education/research sector and 50% were health providers).

Figure 2. Longitudinal trends in the proportion of author affiliations in the education/research sector (filled dots, solid lines) and health providers (empty dots, dotted lines) for published manuscripts over the study period.
Figure 3. Longitudinal trends in the proportion of different research designs used over the study period. Experimental designs including RCT, non-RCT, cohort, case control and uncontrolled experiments (filled black dots, dashed line), cross-sectional surveys (empty dots, dotted line), and anecdotal evidence (filled grey dots, solid line).
sample size and age data are presented for all studies where relevant (excluding anecdotal evidence, expert committee, and narrative reviews)

median sample size in 1960 was 1 (sample size data of n=1 was provided in seven case studies)

sample age and gender data were not available in audited articles published in 1955

Figure 4. Longitudinal change in (a) sample size (median), (b) sample age and (c) percentage of studies sampling both male and female participants.
Figure 5. Longitudinal change in the mean number of times research articles published in Physical Therapy were cited.

* in 2000, the mean value of 50.7 was due to three articles that received a high number of citations (times cited; n=105\textsuperscript{37}, n=221\textsuperscript{38}, n=245\textsuperscript{39})
Appendix 1. Bibliometric audit tool (BAT).

<table>
<thead>
<tr>
<th>JOURNAL REFERENCE, NUMBER PUBLISHED MANUSCRIPTS</th>
<th>THIS ISSUE, IMPACT FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESEARCH DESIGN &amp; SCORE</td>
<td></td>
</tr>
<tr>
<td>SAMPLE</td>
<td></td>
</tr>
<tr>
<td>• Size (n, if reported)</td>
<td></td>
</tr>
<tr>
<td>• Power calculation (yes/no)</td>
<td></td>
</tr>
<tr>
<td>• Age range (upper/lower range(s), if reported)</td>
<td></td>
</tr>
<tr>
<td>• Age group (children, youths, adult, older persons)</td>
<td></td>
</tr>
<tr>
<td>• Gender (n, males; n, females; if reported)</td>
<td></td>
</tr>
<tr>
<td>TOPIC</td>
<td></td>
</tr>
<tr>
<td>• Keywords (recorded verbatim)</td>
<td></td>
</tr>
<tr>
<td>• Number of keywords</td>
<td></td>
</tr>
<tr>
<td>OUTCOME MEASURES</td>
<td></td>
</tr>
<tr>
<td>• Number of reported outcome measures</td>
<td></td>
</tr>
<tr>
<td>• Category (objective, self reported, composite – for each measure)</td>
<td></td>
</tr>
<tr>
<td>STATISTICS</td>
<td></td>
</tr>
<tr>
<td>• Descriptive vs inferential</td>
<td></td>
</tr>
<tr>
<td>TABLES</td>
<td></td>
</tr>
<tr>
<td>• Number</td>
<td></td>
</tr>
<tr>
<td>FIGURES</td>
<td></td>
</tr>
<tr>
<td>• Number</td>
<td></td>
</tr>
</tbody>
</table>
- Type (univariate, bivariate, multivariate – for each figure)

**DIAGRAMS / FIGURES / TABLES**
- Hand drawn vs type set

**PAGES**
- Number (article)
- Number (journal)

**AUTHORSHIP**
- Number of authors
- Number of institutions / affiliations
- Number and country of all authors / affiliations
- Qualification (if reported, recorded verbatim)
- Type of affiliation (hospital, private practice, university, research institute)

**FUNDING**
- If reported
- External (government, industry, charitable, internal)

**REFERENCES**
- Number
- Times cited
Appendix 2. Research design categorization according to research question (BAT) *
* For studies using multiple research designs, they were scored according to the ‘higher’ level of evidence used. Qualitative studies were allocated to a separate ‘qualitative’ research design.

<table>
<thead>
<tr>
<th>Score</th>
<th>Intervention</th>
<th>Diagnostic accuracy</th>
<th>Prognosis</th>
<th>Aetiology</th>
<th>Screening intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Systematic review of level II studies</td>
<td>Systematic review of level II studies</td>
<td>Systematic review of level II studies</td>
<td>Systematic review of level II studies</td>
<td>Systematic review of level II studies</td>
</tr>
<tr>
<td>5</td>
<td>RCT</td>
<td>Study of test accuracy (independent blinded comparison, valid reference standard in consecutive persons with defined clinical presentation)</td>
<td></td>
<td></td>
<td>RCT</td>
</tr>
<tr>
<td>4</td>
<td>Non-RCT</td>
<td>Study of test accuracy (independent blinded comparison, valid reference standard in consecutive persons with defined clinical presentation)</td>
<td></td>
<td></td>
<td>Non-RCT</td>
</tr>
<tr>
<td>3</td>
<td>Cohort</td>
<td>Comparative study of test accuracy with concurrent controls</td>
<td>Cohort study of persons at different stages of their disease</td>
<td>Retrospective comparative study of aetiology / aetiological factors</td>
<td>Cohort</td>
</tr>
<tr>
<td>2</td>
<td>Case control</td>
<td>Diagnostic case-control study</td>
<td>Case control</td>
<td>Case control</td>
<td>Case control</td>
</tr>
<tr>
<td>1</td>
<td>Uncontrolled experiment</td>
<td>Uncontrolled experiment (including subjects as own control, reliability studies)</td>
<td></td>
<td></td>
<td>Uncontrolled experiment</td>
</tr>
<tr>
<td>1</td>
<td>Cross- sectional survey</td>
<td>Cross-sectional survey</td>
<td>Cross-sectional survey</td>
<td>Cross-sectional survey</td>
<td>Cross-sectional survey</td>
</tr>
<tr>
<td>1</td>
<td>Case study</td>
<td>Case study</td>
<td>Case study</td>
<td>Case study</td>
<td>Case study</td>
</tr>
<tr>
<td>0</td>
<td>Expert committees</td>
<td>Expert committees</td>
<td>Expert committees</td>
<td>Expert committees</td>
<td>Expert committees</td>
</tr>
<tr>
<td>---</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>0</td>
<td>Narrative review</td>
<td>Narrative review</td>
<td>Narrative review</td>
<td>Narrative review</td>
<td>Narrative review</td>
</tr>
<tr>
<td>0</td>
<td>Anecdotal</td>
<td>Anecdotal</td>
<td>Anecdotal</td>
<td>Anecdotal</td>
<td>Anecdotal</td>
</tr>
</tbody>
</table>
Modified National Health and Medical Research Council (NHMRC) Evidence Hierarchy

6  Systematic review or evidence based clinical guidelines
   • 2 or more RCTs
   • systematic location, appraisal & synthesis of evidence from scientific studies
   • including explicit details search strategy, inclusion/exclusion criteria etc

EXPERIMENTAL STUDIES
5  Randomised controlled trial (RCT)
   • true random allocation
   • intervention/Rx, or control/placebo groups
   • study of test accuracy (independent, blinded comparison, valid reference standard in consecutive persons with defined clinical presentation)
   • comparison of outcomes

4  Non-randomised controlled trial (non-RCT)
   • ‘pseudorandomised’ - non random allocation method
     eg: alternate allocation, allocation by days of week or admission
   • ‘clustered’ - subjects randomised to Rx/control in groups
   • study of test accuracy (independent blinded comparison, valid reference standard in consecutive persons with defined clinical presentation)

COMPARATIVE (non-randomised and observational) STUDIES
3  Cohort (concurrent control)
   • outcomes compared for a group receiving Rx/intervention/test procedure being studied concurrently with control subjects receiving comparison Rx/intervention/test (usual care)
   • prospective (or retrospective) – 1 group at least prospective
   • defined group followed over time (into future from present, or from past records to present)
   • outcomes compared of people in subsets (Rx or other factor being studied)

2  Case control
   • comparison between subjects with outcome of interest (case) and same population without outcome of interest (control) or diagnostic case-control study
   • seeks association between outcome and prior exposure to risks
   • usually retrospective

1  Uncontrolled experiment
   • pre/post test studies
   • outcomes measured in subjects before and after exposure to Rx/intervention/risk factor/test procedure for comparison
   • includes subjects as own controls (eg reliability/validity and specificity/sensitivity studies)

1  Cross-sectional survey
   • no intervention
   • survey of participants or audit of medical records/data

1  Case study / Case series
   • single groups of subjects exposed to Rx/intervention/diagnosis/test
   • post test measures only

0  Respected authorities / Expert committees
   • eg: taskforce guidelines not explicitly based on research/best evidence

0  Narrative review
   • referenced review of experimental and comparative studies
   • non-systematic search strategies (no explicit details of search strategy)

0  Anecdotal / someone once told me
   • personal opinion (eg: Editorial)
   • non peer reviewed & no clear authority/professional body/affiliation
Sixty-Five Years of Physical Therapy: Bibliometric Analysis of Research Publications From 1945 Through 2010
Louise Wiles, Lisa Matricciani, Marie Williams and Timothy Olds
PHYS THER. Published online December 22, 2011