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Regression Analysis of Research Trendlines for Clinical Articles Published on Medicine & Science in Sports & Exercise between 2009–10 and 2023–24

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Abstract

The purpose of this study was to analyze trendlines based on clinical articles published on *Medicine & Science in Sports & Exercise* (MSSE). Clinical articles published on MSSE from 2009-10 to 2023-24 were reviewed. The yearly numbers of these articles were counted by two reviewers for an interrater reliability and fitted with five types of regression equations. The best one fitted with the highest R^2 was selected to describe a trendline. If it has ascending and descending stages, each stage was fitted in a linear regression equation. A total of 631 clinical research articles (M = 42.07/per year) were identified. An interrater reliability coefficient of 90% was obtained. The best fitted equation was a quadratic polynomial equation, Y = -25.55 + 5.67X - 0.35X2, R^2 = 0.47, $F(2, 12) = 5.37$, p = 0.02, showing a flatted hill-shape, including an ascending stage from 2009-10 to 2016-17 and a descending stage from 2016-17 to 2023-24. In the stage from 2029-10 to 2016-17, the linear regression equation, $Y = 29.89 + 2.69X$, $R^2 = 0.69$, $F(1, 7) = 13.82$, $p = 0.01$, was fitted, noting that the yearly number of clinical articles has increased with a rate of 2.69 articles a year. In the stage from 2016-17 to 2023-24, a linear regression equation, $Y = 54.71 - 2.63X$, $R^2 = 0.44$, $F(1, 7) = 4.76$, $p = 0.07$, was obtained,

indicating that the number of clinical articles has decreased with a rate of 2.63 articles per year. These results documented that the clinical studies from 2009-10 to 2023-24 demonstrate a flatted hill-shape trendline, in which the first stage from 2009-10 to 2016-17 has increased, while the second stage from 2016-17 to 2023-24 has decreased. It seems that currently, there is a need for clinical researchers to increase clinical research activities.

Keywords: *Regression analysis, Research trendlines, Clinical articles, and Medicine and science in sports and exercises*

1. Introduction

Over the past several decades, the growth of scientific publication has been widely recognized as a key indicator of research development and scholarly impact within a professional field. Quantitative analyses of publication trendlines offer insight into how a field evolves, what topics dominate, and where future research may be headed [1] [2]. In sports and exercise science, tracking the progression of research output across time not only reveals disciplinary maturity, but also identifies emerging gaps that warrant further attention.

Within this context, *Medicine & Science in Sports & Exercise* (MSSE), holds a prominent place as the flagship journal of the American College of Sports Medicine (ACSM). It has consistently published studies advancing knowledge on exercise physiology, biomechanics, and clinical applications of sports medicine. Despite the growing emphasis on evidence-based practice and translational research, the extent to which clinical studies within MSSE have evolved quantitatively over time remains underexamined.

Previous bibliometric studies in MSSE have often described research productivity in broad terms—such as topic frequency, citation metrics, or geographic authorship distribution—but have seldom applied regression-based modeling to quantitatively characterize research trendlines in publication output in MSSE [1] [3]. However, several studies in other fields have used regression analysis to offers an empirical means to model how publication counts changed over years and to predict future directions in their professional fields.

Zhang et al. [5] fitted that a linearly increasing trendline over years for research abstracts published under adapted physical activity in *Research Quarterly for Exercise and Sport* (RQES) – Supplements. Guo et al. [4] noted that publication output in sports medicine trendlines to

follow logistic growth. Bornmann and Mutz [1] reported that scientific publication output across many disciplines exhibits “S-shaped” growth patterns. Zhang et al. [6] found a cubic polynomial trendline over years on research articles published on *Palaestra* from 1984 to 2025.

Understanding such trendlines is essential for describing how research development in clinical sports and exercise science progresses through expansion or decline, in which changes in growth rate may reflect the influence of global trends, policy changes, funding priorities, and technological advances affecting clinical research dissemination [6]. As no regression studies were found in MSSE, there is a need existing for MSSE researchers to employing regression analysis to fit research trendlines of clinical auricles published on MSSE over years.

The present study addresses this need by applying regression analysis to determine whether the research trendlines of clinical articles published in MSSE from 2009-10 to 2023-24 follows a linear, curvilinear, or other form of relationship across time. The purpose of this study was to (a) analyze research trendlines based on yearly publication counts of clinical research articles in MSSE, (b) determine the best-fitting regression equation for describing those trends, and (c) interpret what these findings imply for the development of clinical exercise science research.

2. Methodology

2.1. Research Design

This study employed linear and curvilinear regression analysis to examine research trendlines of the research articles published on MSSE between 2009-10 and 2023-24. Five types of regression equations, including exceptional, linear, logarithmic, polynomial, and power, were employed to identify and describe and research trendlines of research articles published on MSSE [5] [6] [8].

2.2. Data Source

This study reviewed all clinical research articles published in MSSE between 2009-10 and 2023-24. Annual publication counts were determined by two independent reviewers who identified and classified articles as “clinical research” based on study design and participant characteristics. Articles involving human participants and addressing clinical outcomes—such as rehabilitation, disease prevention, or health intervention effects—were included. Nonclinical or purely laboratory-based investigations were excluded.

2.3. Reliability Procedure

Two reviewers were trained how to code an article identified based on the above criteria. A reviewer independently coded all research articles identified based on the above criteria, while another reviewer independently double-coded a random 20% subset of articles. The interrater reliability was calculated using the method, consistent with content analysis standards [9]. Discrepancies were resolved through the discussion until the complete consensus with a full agreement (100%) was reached for the final dataset.

2.4. Data Analysis

Yearly frequencies of the research articles identified were calculated for each of the 15 years from 2009-10 to 2023-24. Five regression equations were calculated based on yearly frequencies, in which frequencies being used as the dependent variable (y), while years were used as the independent variable (x). These five regression models [9] fitted based on the research articles were (a) linear, (b) exponential, (c) power, (d) polynomial, and (e) logarithmic. The coefficient of the determination (R^2) for each equation was calculated to determine which equation provided the best fit for the dataset with higher R^2 indicating a equation that more accurately captures the trendline in the dataset [6][10]. All regression equations were fitted using Excel's data analysis procedures [10].

Five regression equations [9] were used to examine trendlines depending on the underlying pattern of the data. A linear model ($y = a + bx$) captures a constant rate of change for the relationship between variables appears steady and directional. An exponential model ($y = ae^{bx}$) describes trends in which growth or decay occurs at a multiplicative rate producing curves that rise or fall increasingly rapidly. A power model ($y = ax^b$) is used if the relationship follows a scaling pattern with changes that depend on a magnitude of predictor. A quadratic polynomial model ($y = a0 + a1x + a2x^2$) allows for a curvature in a curve with 2 segments resulted from a turning point when the dataset change its direction. Finally, a logarithmic model ($y = a + bln[x]$) captures a relationship of rapid early changes gradually taper off for diminishing returns or stabilization effects. Together, these five models offer flexible tools for characterizing a wide range of linear and nonlinear trendlines.

The use of regression analyses to analyze trendlines in annual publication outputs over years of a professional journal is the approach used (a) to test if a trendline exists at a statistical level of significance (e.g., $p < .01$ for 99% of probability or confidence), (b) to quantify a rate of change per year over time (e.g., $b = 0.5$ for increasing 0.5 articles a year), and (c) to compare trendlines

across different studies (e.g., MSSE and RQES) or between different stages (e.g., the first stage and the second stage within the trendline of research articles). Regression analyses for temporal trendlines in annual publication outputs have been used in several document analyses in kinesiology [5][12].

Based on visual inspections of the raw data trendline and the best fitted regression results, the 15-year history was divided into two distinct stages for a more nuanced analysis. Segmented linear regression was then applied to each of the two stages separately. The analysis involved fitting a unique linear regression equation to the data points within each of the defined stages (years from 2009-10 to 2016-17 and years from 2016-17 to 2023-24). The R^2-value, F-value, and p-value used for the slope of each linear equation were calculated to determine the strength and statistical significance of the trendline within each stage.

2.5. Line Graphs

Annual frequencies calculated, trendlines fitted based on a best regression model, and linear trendlines in each of the two stages are presented in a figure with x-axis for frequencies and y-axis for years. The rationale of using line graphs, not bar graphs, in this figure is because line graphs show trendline directions, visually continued, with inferential statistics, which can be used to compare different lines over years [12]. If using bar graphs, it is difficult to see an overall trend direction since they are visually fragmented and without inferential statistics, which is hard to be used to make comparisons among different bars over years [13].

3. Results

3.1. Interrater Reliability of Coding Publications

Interrater reliability between the two independent reviewers was calculated at the 90% of agreement. Discrepancies were resolved through the discussion, which yielded the complete consensus with a full agreement (100%) being reached for the final dataset.

3.2. Descriptive Overview of Total Articles Found

A total of 631 clinical research articles were identified in MSSE over the 15-year period from 2009-10 to 2023-24. A mean of approximately 42 articles per year was calculated.

3.3. Research Trendlines over the 15-Year Period

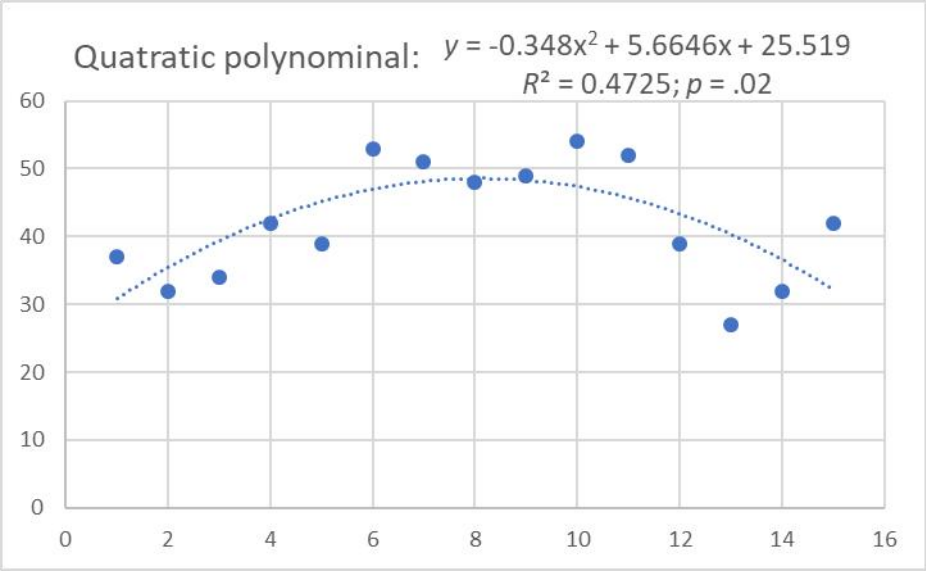
To determine the best-fitting model for the research trendline, five regression equations were computed. As noted in Table 1 below, the quadratic polynomial regression equation yielded the highest R^2 value (0.473) among R^2s fitted from five regression equations.

Table 1. Five R^2s from the Five Types of Regression Equations Fitted

#	Name	Equation Fitted	R^2
1	Linear regression	$y = 0.097x + 41.295$	0.003
2	Exceptional regression	$y = 40.839e^{0.00011x}$	0.001
5	Power regression	$y = 37.182x^{0.055}$	0.040
4	Polynomial regression	$y = -0.348x^2 + 5.655x + 25.519$	0.473
3	Logarithmic regression	y = 2.562In(x) + 37.295	0.053

Note. "*y*" = articles and "*x*" = years between year 2009-10 and year 2023-24.

The quadratic polynomial equation provided the best overall fit, indicating a moderate correlation between year and publication count. It revealed a flattened, hill-shaped curve, suggesting that research activity increased steadily during the early years (2009-10 to 2016-17) and then gradually declined from 20116-7 to 2023-24 (see Figure 1 below).



Note. Vertical (y) - axis = articles and horizontal (x) - axis = years from

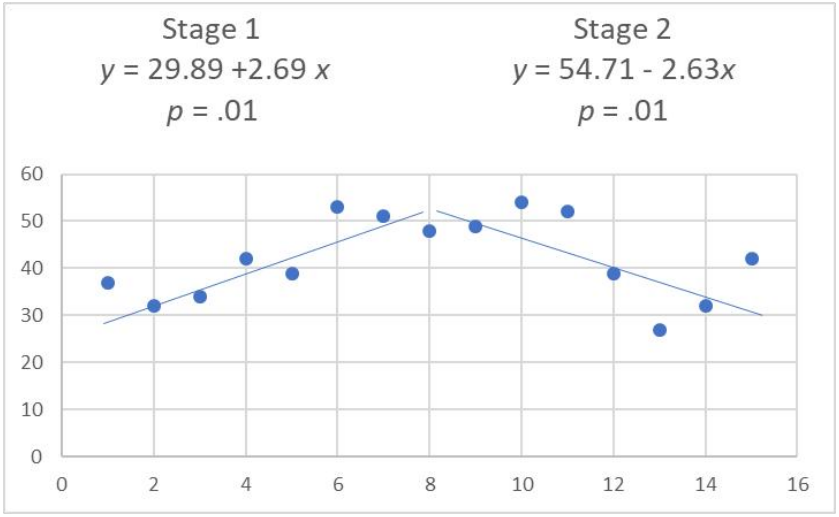
0 = 2008-2009 to 16 = 2024-2025

Figure 1. Trendline Fitted with the Quadratic Polynomial Equation

The above trendline pattern illustrates that clinical research productivity within MSSE rose during the first half of the observed period, peaking around the mid-2010s, before experiencing a gradual reduction in later years.

3.4. Segmented Analysis for Two Linear Stages

Visual inspection of both the raw data line and the fitted line as noted in Figure 1 above, the datasets were segmented into two phases, which should be used for a more detailed linear trend analysis within each of the two stages. These phases were determined based on visual breaks in the data and the inflection points of the quadratic polynomial regression curves. The results of the segmented linear regression equations fitted are presented in Figure 2 below.



Note. Vertical (y) - axis = articles, horizontal (x) - axis = Years

from 0 = 2008-2009 to 16 = 2024-2025

Figure 2. Trendlines Fitted with Linear Regression Equation

As show in Figure 2 above, Stage 1 (2009–2016) displayed a positive linear trend, showing a consistent increase in the number of clinical research articles published each year. The slope indicated an average annual growth of approximately 2.7 articles per year, with a moderately strong fit ($R^2 = 0.69$). In contrast, Stage 2 (2017–2024) revealed a slight downward linear trend, corresponding to a decrease of about 2.6 articles per year on average ($R^2 = 0.44$). This decline suggests a slowdown in clinical research output following the mid-2010s peak.

4. Discussion

4.1. Interpretation of the Research Trendline

The results indicate that the progression of clinical research publications in MSSE over the 15-year period from 2009-10 to 2023-24 does not follow a simple linear growth trendline pattern. Instead, the trendline exhibits a flattened, hill-shaped trajectory, reflecting an initial period of gradual increase from 2009-10 to 2016-17, followed by a late period of gradual decline from 2016-17 to 2023-24.

This curvilinear shape implies that the growth of clinical research in sports and exercise science may have reached a saturation point by the mid-2010s (2016-17). The early increase could reflect broader global trends in evidence-based practice, increased emphasis on clinical trials, and the establishment of translational research frameworks [14]. Conversely, the decline after 2016-17 may correspond with several possible factors, including changes in funding priorities, the emergence of new research topics (e.g., molecular exercise physiology, big data analytics), and a gradual shift toward interdisciplinary or open-access publication venues outside MSSE.

4.2. Comparison with the Previous Literature

Previous studies in related fields have also observed publication trajectories. Some results found in previous studies were contrary to the finding obtained in this study, while some results found in previous studies were in support of the finding obtained in this study. For example, the results found by Zhang et al. [4] documented that research abstracts published on *RQES* - supplements demonstrated a linearly increasing trendline over years 1968 – 2006, which was contrary to the finding with the curvilinear trendline obtained in this study. However, some results found in previous studies were in support of the curvilinear trendline finding obtained in this study.

Guo et al. [4] noted that publication output in sports medicine tends to follow logistic growth, with a period of rapid expansion followed by leveling off as the field matures. Similarly, Bornmann and Mutz [1] reported that scientific publication output across many disciplines exhibits “S-shaped” growth patterns as research communities expand, stabilize, and occasionally contract. Zhang et al. [6] analyzed research articles published on *Palaestra* from 1984 to 2025 in curvilinear regression models, confirming that the APA research trendline has enveloped in a cubic polynomial trendline over years 1984-2025.

Clearly, the above curvilinear trendline findings documented in the previous studies, although these previous finding are not exactly same as the quadratic polynomial trendline found in this

study (i.e., the hill-shaped trendline was observed in MSSE's clinical research articles from 2009–2024), were in support of that the progression of clinical research publications in MSSE over the 15-year period from 2009-10 to 2023-24 did not follow a simple linear growth trendline pattern, but a curvilinear trendlines. Since many factors would be impacted on the development of a profession over years, it seems that a curvilinear trendline would be expected over a relatively longer period of times, but it would be possible that a linear trendline could be found over a relattively shorter period of time.

4.3. Implications for Clinical Exercise Science

From a practical standpoint, the findings suggest a potential need to reinvigorate clinical research efforts within the sports and exercise science community. Given that clinical studies provide the evidence base for applied interventions and policy, a decline in publication counts could slow the translation of scientific knowledge into clinical practice. Moreover, identifying the timing of these trend shifts enables professional organizations such as ACSM to evaluate how their strategic initiatives, conference themes, and funding mechanisms influence scholarly output.

4.4. Limitations of This Research Manuscript

While regression modeling employed in this study provides valuable insights, several limitations should be acknowledged. The first is publication source restriction**.** The analysis was limited to one journal (MSSE). Although it is the flagship journal, inclusion of additional journals could provide a broader perspective. The second is categorization criteria**.** Determining which articles constituted "clinical research" may involve subjectivity despite high interrater reliability. The third is time lag and external factors. Broader events such as the COVID-19 pandemic (2020–2021) likely influenced research productivity and publication priorities, potentially affecting observed trends. Future research could extend this analysis using cross-journal bibliometric data, incorporate topic modeling or citation analysis, and test predictive models that project research trends beyond 2024.

5. Conclusion

This study applied regression analysis to examine 15 years of clinical research publication data in MSSE. The findings revealed a flattened, hill-shaped trendline, characterized by an increase in publication frequency from 2009-10 to 2016-17, followed by a gradual decline through 2023-

24. The results suggest that the development of clinical research in sports and exercise science has reached a transitional phase. To sustain progress, academic institutions, professional organizations, and funding agencies should prioritize initiatives that encourage new lines of clinical inquiry, mentorship, and collaborative research efforts. Future investigations should monitor ongoing publication patterns and explore the underlying factors contributing to the observed decline. Through such analyses, the field can maintain a robust evidence base to support the continued advancement of clinical exercise science.

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