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Digital Transformation, ESG Performance, and Advanced Development of Sports Enterprises: Empirical Evidence from Listed Sports Companies on China's Shanghai and Shenzhen Stock Exchanges

Cong Cen[1], Weiquan Deng[2,*], Long He[3], Xinhuan Zhan[4], Kuo Shi[5]

[1] School of Physical and Health Education, East China Jiaotong University, Nanchang, China

[2] School of Physical and Health Education, East China Jiaotong University, Nanchang, China

[3] School of Physical and Health Education, East China Jiaotong University, Nanchang, China

[4] School of Physical Education, Jiangxi University of Finance and Economics, Nanchang, China

[5] School of Software and Microelectronics, Peaking University, Beijing, China

[*] Corresponding Authors: Weiquan Deng. Email: 695408132@qq.com

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Abstract: From 2012 to 2022, this research examines publicly traded sports companies on the Shanghai and Shenzhen stock exchanges in China, focusing on the impact of digital transformation and ESG performance on the advanced development of these enterprises. The findings reveal that digital transformation and ESG performance both positively contribute to the advanced development of sports enterprises, demonstrating a synergistic effect. Heterogeneity analysis reveals that ESG (Environmental, Social, and Governance) performance has a more significant impact on non-state-owned and sports goods manufacturing enterprises. In contrast, digital transformation demonstrates greater effectiveness within state-owned enterprises. Furthermore, the research highlights the importance of corporate governance, noting that optimized governance structures can enhance the implementation of digital and ESG strategies and improve overall productivity. The study recommends that enterprises should optimize governance mechanisms and balance resource allocation when advancing digital and ESG investments, and that the government should provide appropriate support and aid to promote the advanced development of sports enterprises.

Keywords: Sports Enterprises; Digital Transformation; ESG Performance; Advanced Development; New Quality Productivity

1. Introduction

In January 2024, during the eleventh collective study session, President Xi Jinping highlighted that "developing new quality productivity is an intrinsic requirement and a crucial focus for promoting

advanced development," emphasizing that the essence of advanced development lies in advanced productivity. Furthermore, President Xi underscored the significance of advancements in sports, stating that sports strength is a key manifestation of national comprehensive strength and advocated for accelerating China's transition to a sporting powerhouse. Significant advancements in the Chinese sports industry not only draw strength from a favorable macroeconomic environment encompassing political, economic, social, and cultural aspects but also rely significantly on the advanced progression of sports enterprises themselves. Concurrently, the importance of digital transformation for the advanced development of sports enterprises cannot be overlooked. The concept of digital transformation was first introduced by IBM in 2012, aimed at fundamentally altering traditional business models through the adoption of digital technologies. As reported in the 'China Digital Economy Development Report (2022)', China's digital economy was valued at 45.5 trillion yuan in 2021, representing nearly 40% of the GDP, as there is an upsurge in the digital economy offering emerging advancement new development opportunities for all enterprises. Sports enterprises, under this trend, have begun integrating digital strategies such as employing smart technologies, developing online sports content, and innovating digital marketing approaches, injecting significant momentum into advanced development. Additionally, the crucial nature of ESG (Environmental, Social Responsibility, and Corporate Governance) performance in enterprise management and operations is becoming increasingly prominent. Since the introduction of the ESG concept by the United Nations Global Compact, it has been widely recognized as a core long-term development strategy for enterprises. Sports enterprises not only play a role in providing entertainment and promoting health but also shoulder significant responsibilities in environmental protection and social responsibility. Thus, the core values of advanced development for sports enterprises align closely with ESG performance, making the practice of ESG principles a necessary path for their development.

Given this, a significant correlation exists between digital transformation, ESG performance, and the progressive development of sports enterprises. First, digital transformation represents a pivotal trend in contemporary enterprise development, involving the use of digital technology and data assets to create new value, enhance efficiency, improve decision-making processes, and raise the quality of products and services. Second, stakeholder theory suggests that good ESG performance not only enhances a company's social image but equally attracts and retains more customers and investors, thus supporting advanced development. Therefore, advanced development mandates enterprises prioritize both digital transformation and social and environmental benefits, achieving harmony in economic, social, and environmental development. However, literature linking digital transformation with ESG performance and exploring their combined effects on enterprise development is scarce. Existing studies show that integrating digital technology with ESG governance can enhance enterprises' ability to manage digital transformation risks at a lower cost, thereby promoting advanced development. Li (2022) found through the FGLS model that the integration of digital transformation and ESG performance can enhance enterprise technological cooperation capabilities, thereby improving total factor productivity.

These studies indicate a positive synergy between digital transformation and ESG performance. Yet, Resource Dependence Theory suggests that enterprises are limited by the scarcity of resources, and investing in digital transformation while meeting ESG demands can lead to competitive resource allocation, producing a "give-and-take" effect. As Wang Yinghuan (2023) points out, the interdependence between digital transformation and ESG performance is not solely cooperative but can also have a "double-edged" effect. In practice, digital transformation and ESG performance might compete, as stated by the World Economic Forum, with devices related to digital technology already directly generating 2% of global greenhouse gas emissions during their production, use, and disposal stages.

Hence, exploring the interplay between digital transformation, ESG performance, and the progressive growth of sports enterprises becomes essential. This study analyzes data from sports-related companies listed on the Shanghai and Shenzhen stock exchanges over the decade from 2012 to 2022. It integrates these elements into a unified research framework to investigate: (1) the influence of digital transformation and ESG performance on the progression of sports enterprises; (2) the competitive dynamics between digital transformation and ESG performance in fostering this progression; and (3) the variability and significance of these factors across different sports enterprises in China, considering their diverse characteristics and sizes. The goal is to furnish both theoretical insights and practical guidance to enhance the development of the sports industry.

2. Literature Review and Research Hypotheses

2.1 The Impact of Digital Transformation and ESG Performance on the Advanced Development of Sports Enterprises

Firstly, digital transformation acts as a pivotal catalyst for the progressive development of sports enterprises, fundamentally transforming traditional sports management and operational models. This transformation encompasses changes across multiple dimensions from optimizing athlete training and devising game strategies through data analytics, to enhancing spectator experiences and promoting online streaming and interactive platforms. Studies indicate that digital transformation facilitates improvements in cost-effectiveness, resource optimization, and digital collaboration, not only enhancing operational efficiency and sustainable development but also deepening commitments to environmental and social responsibilities, thereby carving new paths for advanced development in sports enterprises. According to signal theory, sports enterprises leverage digital technologies to enhance operational efficiency and significantly improve their responsiveness to market demands, as well as their ability to communicate key information to the market, thus shifting the industry from an extensively driven development model based on "traditional factors" to a refined "data-driven" model. This transition plays a crucial role in their ability to minimize energy consumption, boost energy efficiency, and pursue sustainable development. Furthermore, agency theory suggests that digital transformation simplifies communication between principals and agents by enhancing information

transparency and transmission efficiency, thereby strengthening sports organizations' ability to convey information to the capital markets. This could not only capture the interest of media and investors but also increase the likelihood of external oversight, effectively safeguarding against risks associated with information asymmetry and fostering transparency and optimization of internal controls.

Secondly, existing research commonly acknowledges that ESG performance positively impacts high-quality enterprise development. Stakeholder theory emphasizes that enterprises, as part of a socio-ecological-economic system, share a communal destiny with employees, customers, creditors, and the environment. By actively fulfilling ESG responsibilities, enterprises can enhance interactions with stakeholders, thereby garnering their trust and support and establishing long-term stable cooperative relationships. High-quality enterprise development depends on efficient internal operations and collaborative efforts with external stakeholders, thus achieving sustainable development. Competitive strategy theory posits that improved ESG performance not only enhances innovation capabilities, optimizes organizational structures, and business processes but also demonstrates an enterprise's potential for sustainable development, a crucial competitive advantage. The Central Economic Work Conference in December 2023 highlighted that a core indicator of high-quality enterprise development is the enhancement of Total Factor Productivity (TFP), guiding enterprises towards high-quality growth. Related research shows that improvements in total factor productivity are typically reflected in both production efficiency and quality of development. In terms of production efficiency, ESG performance not only innovates enterprise technology, optimizes organizational structures, and enhances human resource quality but also increases transparency and reduces agency costs, directly impacting key elements of enterprise production efficiency and thereby promoting advanced development. In terms of development quality, practicing ESG principles curbs myopic behavior, ensuring enterprises focus on long-term value realization. Moreover, robust ESG performance can further enhance an enterprise's reputation and image, facilitating resource acquisition and increasing sales revenue. For instance, industrial support policies often favor environmentally conscious enterprises; investors are inclined to provide financing to enterprises with strong ESG performance; and consumers perceive enterprises with transparent and strong ESG performance as having greater developmental potential. Especially in times of economic downturn or when enterprises face external uncertainties, those actively fulfilling environmental and social responsibilities can benefit from ethical investments, mitigating the impact of adverse events. Therefore, robust ESG performance is a vital strategy for driving advanced development in sports enterprises.

In summary, higher levels of digital transformation and better ESG performance generally indicate higher total factor productivity, which suggests enduring sustainability and growth prospects for enterprise. Accordingly, this paper formulates the following hypotheses:

H1: Digital transformation positively impacts the total factor productivity of sports enterprises.

H2: ESG performance significantly enhances total factor productivity within sports enterprises.

2.2 The Synergistic and Competitive Relationship between Digital Transformation and ESG Performance in the Advanced Development of Sports Enterprises

Digital transformation and ESG performance not only individually contribute to the advanced development of sports enterprises but also demonstrate potential for both synergistic and competitive interactions. Initially, digital transformation boosts ESG performance by facilitating resource integration and optimizing information utilization. In terms of resource integration, digital transformation enables enterprises to combine digital technologies with traditional production models, facilitating more efficient resource allocation and optimal output within innovative resource frameworks. This contributes to enhanced green innovation capabilities, effectively addressing environmental, social, and governance issues, thereby improving ESG performance. In information application, digital transformation improves the efficiency and quality with which enterprises handle and disclose ESG-related information. On one hand, the vast amount of data accumulated during production and operation, processed through digital technologies, is transformed into standardized, high-quality information, increasing the quantity, quality, and usability of enterprise information. Conversely, enterprises can leverage digital technologies to refine their methods of information disclosure, thereby enhancing the transparency and quality of these disclosures. Moreover, it enhances enterprises' capabilities to perceive and access stakeholder information, helping to more accurately "push" relevant information to stakeholders, addressing their pain points, thereby minimizing informational imbalances and subsequently improving the integrity of information disclosures. Thus, a strong synergistic relationship exists between digital transformation and ESG performance, collectively fostering advanced development in the sports industry.

However, the incremental advantages of digital transformation in boosting ESG performance appear to lessen over time. As the extent of digital transformation escalates, its beneficial influence on ESG performance progressively diminishes. Attributable to bounded rationality, enterprises cannot continually and efficiently leverage the advantages brought by digital transformation. Further, a high level of digital transformation may weaken capabilities in information processing and green innovation, indicating that the relationship between digital transformation and ESG performance is not solely positive but also entails negative effects, together forming a complex synergistic and competitive relationship. This paper posits that with increased investment in digital transformation, enterprises might weaken their ability to fulfill ESG responsibilities, thus affecting advanced development. Firstly, digital transformation requires substantial capital, potentially leading to financial strain as industry upgrades demanded at both strategic and operational levels bring profound changes. Secondly, the integration of digitalization with traditional production and operational models may trigger new business formats, thereby generating additional investment demands. Consequently, enterprises heavily investing in digital transformation might need to reduce other capital inputs or increase short-term financial returns to maintain financial flexibility. Digital technologies can also lead to mismatches

between organizational forms, managerial capabilities, and emerging technologies, increasing hidden costs such as management expenses. As cash flow is vital for enterprise survival, an enhanced focus on short-term financial returns might diminish the enterprise's capabilities in green innovation and long-term performance indicators like green patent outputs. Thirdly, prioritizing short-term financial returns contradicts the principles and objectives of ESG, which is based on a long-term, comprehensive non-financial performance evaluation aimed at sustainable development. A focus on short-term gains makes it difficult for enterprises to concurrently address specific ESG practices and might even lead to increased pollution for economic benefits, hindering improvements in ESG performance. Moreover, the detrimental effects of digital transformation on ESG performance are not constant and may result in escalating marginal losses. As digital transformation intensifies, so too does the complexity of the digital technologies and systems involved, leading to disproportionate expansion in investment demands, amplifying the negative effects of misaligned goals and lack of attention, thereby causing exponential growth in opportunity costs and resulting in increasing marginal losses.

In conclusion, the integration of digital transformation and ESG can initially promote advanced development in enterprises, but as investment demands for digital transformation expand, they will compete with ESG performance, thus diminishing their impact on advanced development. On light of this, this paper formulates the following hypotheses:

H3: A synergistic and competitive dynamic exists between digital transformation and ESG performance, influencing the total factor productivity of sports enterprises.

3. Research Design

3.1 Data Sources

This paper examines 72 sports concept enterprises listed on the Shanghai and Shenzhen A-share markets from December 2012 to 2022 as the research sample, aiming to analyze the impact of ESG performance and digital transformation on the advanced development of sports enterprises, as well as their interaction and relative importance. The corporate financial data and ESG data primarily come from the Wind database, while the foundational data are obtained from the China Stock Market & Accounting Research (CSMAR) database. Additionally, Python 3.10 software's web scraping technology is utilized to obtain the annual reports of relevant enterprises from the Choice database, and word frequency analysis is employed to derive the raw data on digital transformation. For missing values in the dataset, the Juchao Information website and the K-Nearest Neighbor algorithm are used for supplementation. The study excludes three categories of enterprises: (1) those that have not disclosed ESG reports; (2) ST, *ST, and PT category enterprises; and (3) enterprises that were delisted during the period. Data for each of the four quarters annually were collected, and after filtering and removing invalid and missing values, a total of 2,543 valid data points were obtained. Data processing and empirical analysis were primarily conducted using Python 3.10 and Stata 16.0 software.

3.2 Research Design

3.2.1 Dependent Variable

Total Factor Productivity (Tfp_op). Total factor productivity is a key metric of corporate production efficiency11, reflecting the efficiency of a system's use of resources such as labor, materials, and financial capital over a specific period. Essentially, it indicates the optimality of resource distribution. From basic economic theories, the essence of product quality lies in its use-value in meeting actual demands. In the current pursuit of advanced development, the focus of economic growth has shifted towards better meeting the growing living needs of the people, emphasizing the use-value of products or services and the importance of the supply side. For enterprises, the key to achieving innovative, coordinated, green, open, and shared advanced development is to enhance their total factor productivity, as quality factors ultimately reflect on production efficiency.

At present, total factor productivity, as a comprehensive and effective assessment tool, has been widely applied in evaluating advanced development across various sectors including culture, marine, tourism, and manufacturing. Advanced development in sports enterprises also needs to be achieved through the organic unity of structure, efficiency, and value. Therefore, this paper considers total factor productivity as an essential tool to evaluate the advanced development of sports enterprises, clearly revealing the efficiency and quality performance of sports enterprises in their pursuit of advanced development. The variable follows the calculation method for total factor productivity proposed by Lu Xiaodong and Lian Yujun (2012), using the Olley-Pakes method to estimate the production function and total factor productivity. This method not only considers traditional production factors like enterprise production elements and labor capital but also includes hard-to-quantify but crucial factors for development such as technological innovation, institutional environment, human capital quality, factor intensity, and internationalization, all of which collectively influence the production efficiency and competitiveness of sports enterprises, comprehensively reflecting their development level and quality.

3.2.2 Independent Variables

(1) Digital Transformation of the Enterprise (Digital). The corporate annual disclosures not only summarize the annual development strategies, business philosophies, organizational structures, and social responsibilities but also reflect the strategic positioning and management philosophy of the enterprises through their language style [14]. Therefore, the prevalence of keywords related to digital transformation in corporate annual disclosures can serve as an indicator of the enterprise's engagement in digital transformation. Following the research methods of Wu Fei (2021) et al., the digital transformation index of enterprises is subdivided into five sub-items: Application of Digital Technology (ADT), Artificial Intelligence Technology (AI), Big Data Technology (DT), Cloud Computing Technology (CC), and Blockchain Technology (BD)25. The research steps are as follows: First, using Python 3.10 to crawl sports listed companies' annual reports from the Choice database to establish a

preliminary data pool for text analysis. Next, based on the digital word frequency from the CSMAR database and government and industry reports, a series of keywords is selected to construct a lexicon. Then, these keywords are matched with the text of the annual reports, excluding negations and non-self-descriptive content, and the word frequency data is organized in a "company-year" format. Considering that the annual reports may reflect the technological development of the following year, a rolling count method is used to smooth data fluctuations by calculating the average word prevalence of pertinent keywords in the annual reports of a specific year and the years before and after. Finally, the word frequency analysis results are obtained. Considering the significant "right-skewed" nature of such data, this paper logarithmically transforms it.

(2) Corporate ESG Performance (Lnesg). This study employs the comprehensive ESG score provided by the Wind database to assess the ESG performance of enterprises. This assessment system covers three core areas: environmental, social, and corporate governance, including 16 themes, 44 key indicators, and over 300 data points8. It extensively covers various fields, not only integrating the unique characteristics of the Chinese capital market but also updating mechanisms rapidly and efficiently, enabling the immediate capture of enterprises' activities in charitable donations, social responsibility practices, and actions that may negatively impact social benefits, well meeting the needs of this research.

3.2.3 Control Variables

Considering the impact of other variables on the advanced development of enterprises in the study, Abdullah Alajmi (2021) pointed out that firm characteristics and governance features influence how enterprises effectively utilize their resources and manage decisions, thereby significantly affecting production efficiency. Drawing on the research method of Liu Zhibiao (2020), this study selects several firm characteristics and governance features as control variables. For firm characteristics, we include enterprise size (Size), debt-to-asset ratio (Asset_ratio), cash to asset ratio (Cf_ratio), yield on total assets (Roa), Tobin's Q value (Tobin_Q), and years listed (Time). In terms of governance characteristics, audit quality (Audit_quality) is chosen as a control variable. Table 1 provides detailed definitions of these variables.

Table 1: Variable Settings and Descriptions

Variable Type	Variable Name	Variable Symbol	Description
Dependent Variable	Advanced development of Sports Enterprises	*Tfp_op*	Total Factor Productivity estimated through the Olley-Pakes approach.
Independent Variables	Digital Transformation	*Digital*	ln(total number of keywords related to digital transformation disclosed in the annual report + 1)
	ESG Performance	*Lnesg*	ln(overall ESG score from Huazheng Securities)
	ESG Rating	*Esg*	Assigned values from 1 to 9 based on Huazheng Securities ESG rating
Control Variables	Enterprise Size	*Size*	Total assets of the enterprise
	Debt-to-Asset Ratio	*Asset_ratio*	Total liabilities / Total assets
	Cash Flow Ratio	*Cf_ratio*	Net cash flow from operating activities / Total assets
	Return on Assets	*Roa*	Net income - Average balance of shareholder equity
	Tobin's Q	*Tobin_Q*	(Market value of tradable shares + Non-tradable share count * Per share net asset value + Book value of liabilities) / Total assets
	Years Listed	*Time*	ln(current year - year of IPO + 1)
	Audit Quality	*Audit_quality*	0 if the auditing firm is not one of the Big Four accounting firms, 1 otherwise

3.3 Model Specification

To explore the impact of digital transformation and ESG performance on the advanced development of sports enterprises, this study constructs models based on hypotheses H1 and H2. Given the collection of data across four quarters for various enterprises, and considering the occurrence of individual and annual repetitions in the dataset, the research employs a fixed-effects model to estimate the coefficients of the variables. The specific formulas are:

$$Tfp_{op_{it}} = \alpha_0 + \alpha_1 Digital_{it} + \alpha_2 Control_{it} + \cdots + \alpha_p Control_{it} + \alpha_i + \pi_t + \epsilon_{it} \quad (1)$$

$$Tfp\_op_{it} = \beta_0 + \beta_1 Lnesg_{it} + \beta_2 Control_{it} + \ldots + \beta_p Control_{it} + \alpha_i + \pi_t + \mu_{it} \quad (2)$$

In equations (1) and (2), Tfp_op_{it} represents the total factor productivity of enterprise *i* in period *t*, reflecting the state of advanced development of the sports enterprise. $Lnesg_{it}$ denotes the overall ESG performance score of enterprise *i* in period *t*, while $Digitl_{it}$ represents the degree of digital transformation of the enterprise, and $Control_{it}$ is the vector of control variables. α_i and π_t represent individual and time fixed effects respectively, while μ_{it} and ϵ_{it} are the random error terms for the models.

Furthermore, to investigate whether there is a competitive relationship in the impact of digital transformation and ESG performance on promoting advanced development in sports enterprises, an interaction term between digital transformation and ESG performance is introduced in the models as follows:

$$Tfp\_op_{it} = \delta_0 + \delta_1 Digital_{it} + \delta_2 Lnesg_{it} + \delta_3 Digital * lnesg_{it} + \delta_6 Control_{it} + \cdots + \delta_p Control_{it} + \alpha_i + \pi_t + \varepsilon_{it} \quad (3)$$

Referring to the study by Won-Yong Oh (2018)[1], if $\delta_3<0$, it indicates a potential competitive relationship; if $\delta_3>0$, it signifies a cooperative relationship.

4. Empirical Analysis

4.1 Descriptive Statistics and Correlation Analysis

According to Table 2, the means of *Tfp_op*, *Roa*, *Size*, *Cf_ratio*, and *Tobin_Q* are right-skewed, revealing a general advantage in the quality of development among sports enterprises. The standard deviation of *Tfp_op* is 0.487, indicating a high level of consistency in enterprise development. Additionally, the mean value of *Esg* is 4.073, suggesting that enterprises generally achieve a moderate level of ESG performance. However, the substantial standard deviations for ESG ratings (1.033) and digital transformation (1.046) highlight significant differences among enterprises in these areas, implying the necessity of conducting heterogeneity tests. Pearson correlation analysis confirms positive correlations between *Digital* and *Tfp_op* (0.099), and between *Lnesg* and *Tfp_op* (0.084), both significant at the 1% level, providing preliminary validation for hypotheses H1 and H2. Furthermore, the Variance Inflation Factor (VIF) tests for control variables (all mean values below 10) indicate that collinearity among research variables is not significant, offering robust statistical support for the

[1] Oh, W. Y., Chang, Y., & Kim, T. Y. (2018). Complementary or Substitutive Effects? Corporate Governance Mechanisms and Corporate Social Responsibility. *Journal of Management*, 44, 2716-2739.

direction of the research hypotheses.

Table 2: Table of Descriptive Statistics and Correlation Analysis of Variables

VARIABLE	*Tfp_op*	*Digital*	*Esg*	*Lnesg*	*Size*	*Asset_ratio*	*Cf_ratio*	*Roa*	*Tobin_Q*	*Audit_quality*	*Time*
Mean	2.680	3.240	4.073	4.287	2.040	0.405	0.174	0.028	2.034	0.060	2.222
Sd	0.487	1.046	1.033	0.072	1.170	0.199	0.136	0.050	1.128	0.238	0.858
Tfp_op	1										
Digital	0.084***	1									
Esg	0.087***	0.188***	1								
Lnesg	0.099***	0.197***	0.942***	1							
Size	0.076***	0.074***	0.002	0.066***	1						
Asset_ratio	-0.104***	-0.116***	-0.221***	-0.132***	0.272***	1					
Cf_ratio	0.144***	0.089***	0.154***	0.095***	-0.110***	-0.434***	1				
Roa	0.298***	0.152***	0.116***	0.148***	-0.036*	-0.208***	0.227***	1			
Tobin_Q	0.135***	-0.109***	-0.009	-0.096***	-0.132***	-0.190***	0.144***	0.074***	1		
Audit_quality	0.118***	-0.076***	-0.032	-0.083***	0.012	0.144***	-0.034*	0.045**	-0.10***	1	
Time	-0.018	-0.155***	-0.148***	-0.180***	0.169***	0.350***	-0.271***	-0.191***	-0.045**	0.041**	1

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Parentheses contain t-values. The same notation applies below.

4.2 Regression Model Testing

This paper constructs six benchmark regression models with Tfp_op as the dependent variable, as shown in Table 3. To test hypotheses H1 and H2, models (1)-(2) were initially constructed without control variables. The coefficients for Lnesg and Digital are significant (0.587, $p<0.001$; 0.046, $p<0.001$), and remain significant after including control variables in models (3)-(4) (0.406, $p<0.001$; 0.028, $p<0.001$). The significance of models (1)-(4) indicates that digital transformation and ESG performance have a significant positive impact on the advanced development of sports enterprises, supporting H1 and H2.To test hypothesis H3, model (5) was constructed where the coefficients for Lnesg and Digital were adjusted and found significant (0.024, $p<0.001$; 0.353, $p<0.001$), suggesting that the relationship between the two is not entirely competitive. Model (6) builds on (5) by including an interaction term between digital transformation and ESG performance, Digital*lnesg, where the coefficient is significantly negative (-0.351, $p<0.001$), indicating a competitive relationship between them in promoting advanced development in sports enterprises, thus supporting H3.Simple slope analysis reveals that the impact of ESG performance on the advanced development of sports enterprises varies with different levels of digital transformation investment. Under low digital transformation investment levels, a cooperative relationship is exhibited (0.050, $p<0.001$), while at high digital transformation investment levels, this shifts to a competitive relationship (-0.011, $p<0.1$), as detailed in Table 4.

Table 3: Results of Regression Analyses of the Effects and Interactions of Digital Transformation and ESG Performance on The Advanced Development of Sports Firms

VARIABLE	*Tfp_op*(1)	*Tfp_op*(2)	*Tfp_op*(3)	*Tfp_op*(4)	*Tfp_op*(5)	*Tfp_op*(6)
Digital		0.046***(5.01)		0.028***(3.14)	0.353***(2.70)	1.388***(4.07)
Lnesg	0.587***(4.40)		0.406***(3.14)		0.024***(2.71)	1.531***(3.34)
*Digital*lnesg*						-0.351***(-3.29)
Size			4.550***(5.64)	4.65***(5.78)	4.44***(5.50)	4.380***(5.42)
Asset_ratio			-0.142***(-2.59)	-0.126**(-2.29)	-0.119**(-2.16)	-0.108*(-1.96)
Cf_ratio			0.243***(3.25)	0.236***(3.15)	0.233***(3.13)	0.228***(3.05)
Roa			2.545***(13.51)	2.584***(13.80)	2.525***(13.41)	2.520***(13.41)
Tobin_Q			0.057***(6.91)	0.055***(6.70)	0.058***(7.00)	0.060***(7.27)
Audit_quality			0.267***(6.94)	0.258***(6.73)	0.267***(6.94)	0.255***(6.63)
Time			0.035***(3.10)	0.034***(2.97)	0.037***(3.23)	0.038***(3.31)
Obs.	2543	2543	2543	2543	2543	2543
Id	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R^2	0.008	0.010	0.140	0.140	0.142	0.146
Adj.R^2	0.007	0.009	0.137	0.137	0.139	0.143
F	19.39***	25.07***	51.45***	51.45***	46.66***	43.24***

Table 4: Results of Simple Slope Analysis

Level of Investment	Regression Coeffocient	*Sd*	*t*	*p*
Mean	0.019	0.010	1.948	0.051
High Level（+1SD）	-0.011	0.014	-1.751	0.053
Low Level（-1SD）	0.050	0.012	4.255	0.000

4.3 Robustness Tests

This paper conducts robustness tests of the benchmark model from three perspectives: (1) Exclusion of Alternative Explanations: Drawing on relevant literature on the selection of sports-listed enterprises1, enterprises whose main business does not involve sports activities or those only tangentially related to sports themes were excluded. A representative sample of 56 sports-listed enterprises was selected to more accurately reflect the condition of sports enterprises. (2) Substitution of Explanatory Variables: Huazheng Securities' ESG also offers another rating method, classifying enterprises into nine different levels from C to AAA. Following existing research8, a numerical value from 1 to 9 is assigned to each quarterly ESG rating level (from C to AAA) to test the stability of the results. (3) Robust Regression Model: Robust regression is designed to address data issues that violate fixed-effects model assumptions, effectively reducing endogeneity. The test results, as shown in Table 5, indicate that the direction and significance of the regression coefficients across all models align with those of the benchmark regression model, affirming the robustness and reliability of the benchmark results.

Table 5: Robustness Test Results

VARIABLE	Exclusion of Alternative Explanations			Substitution of Explanatory Variables		Robust Regression Model		
	Tfp_op(7)	*Tfp_op*(8)	*Tfp_op*(9)	*Tfp_op*(10)	*Tfp_op*(11)	*Tfp_op*(12)	*Tfp_op*(13)	*Tfp_op*(14)
Digital		0.026** (2.26)	1.516*** (2.82)		0.130*** (3.25)		0.028*** (3.25)	1.448*** (3.51)
Lnesg	0.419*** (2.66)		1.439*** (3.63)			0.426*** (3.48)		1.389*** (4.58)
Esg				0.026** (2.39)	0.128*** (3.90)			
*Digital*lnesg*			-0.353*** (-2.81)					-0.332*** (-3.45)
*Digital*esg*					-0.032***(-3.30)			
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Obs.	1813	1813	1813	1813	1813	1813	1813	1813
Id	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*

4.4 Heterogeneity Tests

Considering China's unique institutional environment, enterprises of different property rights exhibit variations in facing market pressures, capital acquisition, and social responsibilities. This paper categorizes enterprises based on whether the state owns or controls their capital, differentiating state-owned from non-state-owned enterprises. Additionally, given the common practice of diversified business strategies among Chinese sports enterprises, differences in operational content exist. Following the classification method by Yi Wenyu et al. (2023)37, enterprises are divided into sports service enterprises and sports goods manufacturing enterprises based on their primary sports business. This subdivision based on property rights and operational content aims to deepen the understanding of sports enterprises. The detailed classification results are presented in Table 6.

(1) Property Rights: Table 6 illustrates that in model (15) the coefficient for Lnesg is not significant (-0.008, $p>0.1$), while in model (16) the coefficient for Lnesg is significant (0.723, $p<0.001$), suggesting that non-state-owned enterprises experience a stronger positive effect from ESG performance on advanced development. In model (17), the Digital coefficient is significant (0.033, $p<0.1$), whereas in model (18), the Digital coefficient is not significant (-0.021, $p>0.1$), suggesting that state-owned enterprises are more significantly influenced by digital transformation in their advanced development. In model (19), the Digital*lnesg coefficient is not significant (-0.008, $p>0.1$), and in model (20), the coefficient for Digital*lnesg is significant (-0.516, $p<0.001$), highlighting a more apparent competitive dynamic between digital transformation and ESG performance in non-state-owned enterprises.

Table 6: Results of the Analysis of Heterogeneity in the Nature of Business Ownership

VARIABLE	*Tfp_op*(15) state-owned enterprises	*Tfp_op*(16) non-state-owned enterprises	*Tfp_op*(17) state-owned enterprises	*Tfp_op*(18) non-state-owned enterprises	*Tfp_op*(19) state-owned enterprises	*Tfp_op*(20) non-state-owned enterprises
Digital			0.033*(1.93)	-0.021(-1.38)	0.063(0.09)	2.356***(4.77)
Lnesg	-0.008(-0.03)	0.723***(3.67)			0.067(0.07)	2.169***(3.31)
*Digital*lnesg*					-0.008(-0.03)	-0.516***(-3.37)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Obs.	607	1206	607	1206	607	1206
Id	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R^2	0.1143	0.2473	0.120	0.240	0.120	0.258
Adj.R^2	0.1024	0.2422	0.120	0.235	0.105	0.252
F	9.64***	49.15***	10.17***	47.25***	8.11***	41.49***

(2) Operational Content: Table 7 illustrates that in model (21), the coefficient for Lnesg is not significant (0.186, p>0.1), while in model (22), it is significant (0.522, p<0.001), demonstrating that sports goods enterprises experience a more pronounced enhancement in advanced development from ESG performance. In model (23), the coefficient for Digital is significantly negative (-0.019, p<0.1), and in model (24), it is significant (0.019, p<0.1), indicating that the advanced development of sports goods enterprises is more significantly promoted by digital transformation. In model (25), the coefficient for Digital*Lnesg is significant (-0.364, p<0.05), while in model (26), it is not significant (-0.119, p>0.1), suggesting a more apparent competitive effect between digital transformation and ESG performance in sports service enterprises.

Table 7: Results of Business Content Heterogeneity Analysis

VARIABLE	*Tfp_op*(21) sports service enterprises	*Tfp_op*(22) sports goods enterprises	*Tfp_op*(23) sports service enterprises	*Tfp_op*(24) sports goods enterprises	*Tfp_op*(25) sports service enterprises	*Tfp_op*(26) sports goods enterprises
Digital			-0.019*(-1.65)	0.019*(1.05)	-0.022**(0.92)	0.016(1.51)
Lnesg	0.186(1.11)	0.522**(2.15)			0.263*(1.54)	0.442*(1.65)
*Digital*lnesg*					-0.364**(-2.21)	-0.119(-0.62)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Obs.	880	933	880	933	880	933
Id	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R^2	0.313	0.235	0.315	0.232	0.320	0.236
Adj.R^2	0.307	0.229	0.308	0.226	0.312	0.228
F	49.68***	35.52***	49.95***	34.94***	40.87***	28.52***

5. Discussion

5.1 Discussion and Analysis of the Interplay between Digital Transformation, ESG Performance, and Advanced Development of Sports Enterprises

In the context of the digital economy, enterprises face a market environment filled with uncertainties and rapid, widespread information flow. Traditional communication methods, production

models, and sales strategies are no longer sufficient to meet the diversified needs of consumers or to effectively respond to fierce market competition. Consequently, digital transformation has become a key trend for enterprise development, involving the application of digital technologies and data resources aimed at innovating value, enhancing operational efficiency, optimizing decision processes, and improving product and service quality. This process not only facilitates efficient operations but also significantly improves customer experience, spawning new business models and market opportunities. ESG performance, as a crucial indicator of an enterprise's environmental protection, social contribution, and governance structure, not only enhances corporate image but also attracts more customers and investors, providing solid support for high-quality enterprise development. This study finds that both digital transformation and ESG performance promote the advanced development of sports enterprises, corroborating the aforementioned analysis. Furthermore, viewing digital transformation and ESG performance as inseparable dual drivers of high-quality growth is crucial. The infrastructure of an enterprise, integrating technical standards, cultural concepts, regulations, and value orientations, largely reflects the soft power of the enterprise. Infrastructure construction represents the hard power of an enterprise, while the "infrastructure ecosystem" showcases its soft power. Additionally, the concept of advanced development emphasizes that enterprises, while pursuing economic benefit growth, should also value social and environmental benefits to achieve balanced development across economic, social, and environmental spheres.

Moreover, the study finds that the impact of ESG performance on the advanced development of sports enterprises varies at different levels of digital transformation investment. At lower levels of digital transformation investment, a cooperative relationship is exhibited, while at higher levels, the relationship becomes competitive. Reasons for this include: (1) Cooperative Relationship: Within the framework of modern enterprise cooperation, the application of digital technology has significantly reduced operational costs, optimized surplus management, and eased financing constraints, thereby effectively enhancing comprehensive production efficiency. The process of digitalization provides robust support for enhancing ESG performance, as research by Loebbecke and Picot (2015) indicates that digital transformation promotes the efficient reallocation of production resources and improves output efficiency under limited innovation resources. This not only creates a favorable environment for resource integration in the field of green technology but also enhances the green innovation capabilities of enterprises, thereby further boosting ESG performance23. According to stakeholder theory, digital transformation also strengthens the motivation for enterprises to improve ESG performance, driven by increased external scrutiny and the push from sustainability incentives under the dual-carbon goals35. From the perspective of signal theory, exemplary ESG performance, facilitated by digital technology, can project an enterprise's values and strategic directions externally, thereby enhancing its reputation and competitiveness in the market. Hence, enterprises need to achieve higher efficiency and effectiveness through digital transformation while also conveying positive signals through robust ESG performance to achieve advanced development. (2) Competitive Relationship: Firstly, the conceptual

debate centers on the view that investment in digital transformation emphasizes innovation, the application of technology, and rapid adaptation to market changes. This is not merely an investment in physical assets but involves a strategic transformation encompassing technology, talent, and corporate culture, aimed at using digital means to comprehensively enhance enterprise competitiveness and sustainability. However, enterprises often face challenges in achieving true digital reform. In contrast, the traditional resource view tends to attribute outstanding performance to basic organizational resources and capabilities, overlooking the potential impacts of digital technology. Enterprises often ignore the competitive relationship between digitalization and traditional resources, opting instead for a singular perspective. Secondly, resource contention arises as enterprises have limited resources to allocate between digital transformation and ESG activities. Overemphasis on either can lead to the neglect of the other, thereby affecting the comprehensive performance of enterprises in the market and social responsibility. Excessive focus on digital transformation may weaken efforts in ESG performance, and vice versa. Such a singular investment strategy can damage the long-term sustainability and overall competitiveness of an enterprise. Furthermore, management attention is limited; when digital transformation consumes most of the management's time, energy, and resources, they may neglect other objectives, including ESG goals. To rationalize their decisions and maximize the benefits of digital transformation, management often tends to view digitalization as the core competitiveness of the enterprise, thereby diminishing their recognition of the importance of ESG performance.

In summary, both digital transformation and ESG performance serve as catalysts for promoting advanced development in sports enterprises. However, when adopting digital transformation strategies and ESG governance methods, enterprises should be aware of their competitive relationship. This paper contends that in promoting advanced development in sports, to some extent or scope, digital transformation and ESG performance can progress together and develop synergistically.

5.2 Heterogeneity in Property Nature and Business Operations Discussion and Analysis

(1) Property Nature: Firstly, the impact of ESG performance on the advanced development of non-state-owned enterprises is greater compared to state-owned enterprises. The reason is that state-owned enterprises (SOEs), as pillars of the national economy, relatively easily obtain financial support from the government and financial institutions, thereby facing fewer challenges in financing. Moreover, due to their close relationship with the government, SOEs inevitably carry more social responsibilities and are subject to a relatively comprehensive and independent assessment system by the State-owned Assets Supervision and Administration Commission, which weakens their proactivity in ESG development. In contrast, non-state-owned enterprises lack direct support from the government and financial institutions and rely more on enhancing their ESG performance to improve their financing capabilities and competitiveness, thus promoting sustainable development.

Secondly, the impact of digital transformation on the advanced development of state-owned enterprises is more significant. This is due to the policy drive and scale effect experienced by SOEs. On one hand, SOEs often undertake important tasks to achieve national strategic objectives, including

promoting technological advancement and social development. Government policy support and financial investment provide these enterprises with strong motivation and resources, allowing them to make substantial investments in digital infrastructure and technological innovation. Additionally, the scale and market influence of SOEs enable them to play a leading role in driving industry standards and building ecosystems, thereby enhancing overall efficiency and competitiveness.

Thirdly, there is a stronger competitive-cooperative relationship between digital transformation and ESG performance in promoting advanced development in non-state-owned sports enterprises. This is due to the cost sensitivity and organizational adaptability of non-state-owned enterprises, which may not have the same level of resources as SOEs and are more sensitive to costs. Increased investment in digital transformation might lead to improper resource allocation, affecting the financial health and long-term sustainability of the enterprise, particularly in a rapidly changing market environment. Non-state-owned enterprises require higher flexibility and adaptability, and excessive investment in digital transformation may lead them to rely too heavily on technology, neglecting the development of talent and organizational culture, thereby impacting their innovation capacity and market responsiveness. Thus, non-state-owned sports enterprises need to find a more suitable balance between these factors to achieve advanced development.

(2) Business Operations: Firstly, the impact of digital transformation on the advanced development of sports goods manufacturing enterprises is more significant due to the depth and breadth of innovation and digital application. The sports goods manufacturing industry, through significant R&D investment and the adoption of cutting-edge technologies and equipment, such as utilizing virtual simulation technology to enhance design quality, automating production lines to increase efficiency, and leveraging e-commerce platforms to directly reach consumers, has enhanced supply chain efficiency and the speed of goods circulation. These changes have enabled the total factor productivity of sports goods manufacturers to surpass that of sports service enterprises. Meanwhile, sports service enterprises, including fitness and sports venue services, are using digital technology to deepen user profiles and achieve customized product design. The application of social media tools and the introduction of AR and VR technologies offer users immersive marketing experiences, thereby promoting service efficiency. However, the digital transformation of sports service enterprises largely depends on the infrastructure and smart devices provided by the manufacturing sector, and their progress in enhancing productivity is relatively slow.

Secondly, the impact of ESG performance in promoting advanced development is greater in sports service enterprises. This is due to their unique production models and characteristics, which exhibit higher efficiency in interactions with various stakeholders — including government, media, and consumers—effectively reducing information asymmetry. For instance, the successful hosting of sports events relies on cross-organizational collaboration, which naturally fosters information sharing, deepening mutual trust and support. Additionally, the high visibility of sports events brings extensive media exposure, further enhancing corporate transparency. In contrast, sports goods enterprises have

stronger independence in product production, limiting their opportunities to engage in information exchange with stakeholders on an equal footing. Furthermore, the specific environmental demands of sports events drive service enterprises to adopt proactive measures to mitigate their environmental footprint, such as the establishment of NHL indicators for precise water resource management and various large-scale event environmental initiatives, reflecting the sports service industry's commitment to environmental and social responsibilities. Therefore, sports service enterprises not only communicate more effectively with stakeholders during the production process, but their requirements for event environmental quality also make them less sensitive to ESG performance. This characteristic enables sports service enterprises to promote advanced development more effectively through information exchange and the practice of environmental responsibilities, compared to sports goods enterprises.

Thirdly, there is a stronger competitive relationship between digital transformation and ESG performance in promoting advanced development in sports service enterprises. This is primarily due to the competition for resource allocation, changes in market and consumer expectations, and the trade-offs between long-term benefits and short-term costs. As previously analyzed, digital transformation promotes advanced development in sports service enterprises relatively slowly; therefore, significant investments in funds, technology, and human resources are required for digital transformation, necessitating relatively higher costs to achieve better digital transformation outcomes in the sports service industry. Simultaneously, as consumers increasingly focus on health, environmental protection, and social responsibility, the ESG performance of sports service enterprises becomes a crucial factor in attracting consumers, and improvements in ESG performance often take a considerable time to manifest. Therefore, sports service enterprises need to find a more suitable balance between these factors to achieve advanced development.

6. Conclusions and Recommendations

6.1 Conclusions

This study empirically examines the relationship between digital transformation, ESG performance, and the advanced development of sports enterprises listed on China's A-share market from 2012 to 2022. The findings are as follows:(1) both digital transformation and ESG performance significantly enhance the advanced development of sports enterprises, with ESG performance having a more pronounced impact, particularly among non-state-owned and sports goods manufacturing enterprises. In contrast, digital transformation more effectively drives the advanced development of state-owned enterprises. (2) a synergistic yet competitive relationship exists between digital transformation and ESG performance in promoting advanced development. Specifically, when corporate resources are limited, increasing investments in digital transformation may decrease investments in ESG performance, thus transitioning the relationship from cooperative to competitive and reducing resource allocation efficiency. Achieving the synergistic benefits of both requires moderate management and balanced resource distribution. (3)

the competitive dynamic between digital transformation and ESG performance is more evident among non-state-owned enterprises and sports goods manufacturers.

There are several limitations in this study. First, the definition of sports enterprises in China is not yet comprehensive, standardized, or unified, necessitating further exploration of a more precise definition of sports enterprises in future research. Second, the measurement of the level of digital transformation in sports enterprises lacks precision. Third, the ESG rating agency Huazheng, as an independent third party, may have scores and ratings that differ from the actual ESG performance of enterprises due to issues such as "greenwashing" or appeasement strategies. Fourth, this paper explored the competitive effects between digital transformation and ESG performance in the advanced development of sports enterprises but did not discuss the cooperative effects. Future work will further calculate and measure the optimal range of digital transformation and ESG performance to achieve their concurrent promotion of advanced development in sports enterprises.

6.2 Recommendations

First, harmoniously integrate digital transformation with existing corporate resources to create space for investment in ESG performance. Digital transformation is not a complete overhaul; thus, it is crucial to harmonize existing resources with emerging digital technologies to avoid management chaos that could negate potential value brought by business model innovation. True value of digitalization transcends simple internet, software, or hardware applications—it lies in innovations in sales, management, and production processes driven by digital technologies, which build new resource platforms for enterprises. Despite the emergence of numerous new scenes, channels, and technologies in current digital practice, such as e-commerce platforms, mobile app ordering, paperless operations, and remote work, the success of corporate digital transformation depends on the integration level of digital technologies with other corporate resources. Therefore, enterprises should thoughtfully ensure that technology choices match the overall resource configuration of the company, avoiding wasteful resource allocation and advancing steadily in the digital wave to achieve genuine innovation and development.

Second, balance digital investment with ESG governance investment. Given the competitive relationship between digital transformation and ESG performance under limited resources, companies must be more cautious in choosing digital strategies. Depending on their industry position, market demand, and specific characteristics, enterprises should decide whether to adopt a fast or slow digital path. While a fast digital strategy, led by business model innovation, can quickly capture market share, it also bears the risk of management discord. In contrast, a slow digital strategy focuses on gradually accumulating and addressing management challenges brought by digitalization, although it faces a latecomer disadvantage, it is more conducive to long-term stable development. At the same time, while advancing digital transformation, enterprises should not neglect the enhancement of ESG performance. Appropriately allocating resources and balancing the needs of digital investment and ESG improvement is key to avoiding reduced efficiency in resource allocation and promoting high-quality corporate

development. Therefore, when formulating digital strategies, sports enterprises should consider how to capture the market through technological innovation and business model innovation while ensuring that the process continuously enhances ESG performance, achieving the dual objectives of digital transformation and social responsibility.

Third, optimize management mechanisms and accompanying measures to promote the synergistic efficiency of digitalization and ESG. Enterprises, particularly state-owned sports enterprises and sports goods manufacturers, face the need to update their management mechanisms. Fully leveraging the innovative empowerment brought by digitalization, deepening digital strategies beyond "Internet +" and "informatization," and proactively adjusting organizational structures, management methods, and decision-making processes can optimize the coordination of digital technologies with corporate resources. Particularly under the mixed-ownership reform, state-controlled listed companies should streamline decision-making processes, reduce external intervention, relieve state-owned enterprises engaged in market-oriented operations from burdens, and strengthen risk management systems to ensure the safety and efficiency of digital transformation. Moreover, encourage enterprises to explore paths of synergistic efficiency between digitalization and ESG performance. By classifying management and granting appropriate authority, motivate enterprises to actively adapt and lead in the digital wave, jointly advancing the transition to advanced development.

Fourth, provide management and subsidies appropriately. Considering the stronger competitive effects between digital transformation and ESG performance in non-state-owned enterprises and sports goods manufacturers, the government should adopt more precise and efficient support strategies. Government support should not be limited to financial subsidies but should focus more on the overall synergy of corporate management coordination and technology introduction. Given the existing information asymmetry, the government should ensure that subsidies are fairly distributed to truly needy enterprises, especially those non-state-owned enterprises and sports goods manufacturers that show great potential in enhancing ESG performance and undergoing digital transformation, through a more transparent and fair assessment mechanism. This not only avoids the waste of resources but also promotes fair competition among enterprises, stimulates market vitality, and ensures that subsidy policies are transparent and fair. Thus, effectively promote non-state-owned enterprises and sports goods manufacturers to achieve advanced development through enhancements in digital transformation and ESG performance.

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Author Contributions

Cong Cen: Writing, Original draft, Conceptualization, Methodology. Weiquan Deng: Conceptualization, Writing–review & editing, Supervision. Long He: Data curation, Visualization. Yanfeng Zhang: Investigation, Formal analysis. Xinhuan Zhan: Investi- gation, Data curation. Kuo Shi: Supervision, Validation. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials

The data on which the study is based were accessed from a repository and are available for downloading through the following link.

https://data.csmar.com/

https://www.wind.com.cn/portal/zh/EDB/index.html

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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