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Determinants of Viewer Engagement in Health and Sports Videos: A Quantile Regression Forest Machine Learning Approach Applied to Reformer Pilates Content

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ABSTRACT This study assessed the quality, reliability, and popularity of Reformer Pilates videos on YouTube, evaluating educational value, credibility, and viewer engagement using standardized scoring while exploring factors affecting popularity. On November 1, 2024, a YouTube search for "Reformer Pilates" identified the top 70 most-viewed videos. Videos were excluded if irrelevant, promotional, or under 25 seconds. Video quality and reliability were assessed using the Global Quality Scale (GQS), Modified DISCERN (mDISCERN), and JAMA benchmarks. Viewer engagement and popularity were measured with the Video Power Index (VPI). Factors associated with engagement were analyzed using Quantile Regression Forest modeling. Most videos (87.1%) were uploaded by individual channels, 12.9% by Pilates studios. Average GQS (3.06), mDISCERN (3.09), and JAMA (2.61) scores indicated moderate quality and reliability. Videos claiming instructor expertise had lower mDISCERN scores ($p = 0.005$). Studio-recorded videos had higher GQS scores than home-recorded videos, though not statistically significant. Quantile Regression Forest analysis indicated that mentioning safety information, shorter video duration, and higher GQS scores were among the factors associated with higher viewer engagement (VPI). Older videos tended to exhibit lower engagement levels, reflecting a preference for newer content. Findings highlight the importance of high-quality, concise, and safety-focused Reformer Pilates videos, as these characteristics are associated with higher engagement and popularity. Content creators may benefit from prioritizing these factors to attract and retain audiences, underscoring YouTube's role in delivering potentially reliable Pilates content.

KEYWORDS
Machine learning
Reformer pilates
Video power index
YouTube
Viewer engagement

INTRODUCTION

Reformer Pilates is an effective and modern exercise system that supports the foundation of the musculoskeletal system, enhances the movement capacity and quality of the human body, and enables the body to move as a whole by correcting muscle weaknesses and imbalances (Lee 2023; Pereira *et al.* 2022). In Reformer Pilates, individuals engage in exercises in a controlled and focused manner, discovering their movement capacities (Lim and Hyun 2021). This makes the exercise more beneficial and improves the quality of individuals' daily life activities. Moreover, Reformer Pilates has become a commonly preferred method in the treatment processes of orthopedic problems in the muscles and joints (Rangabprai *et al.* 2024). In athletes, it is frequently chosen to enhance performance and accelerate the recovery process after injuries (Kaner and Ayer 2022). As Reformer is a functional and complex piece of equipment, ensuring multifaceted physical development and maintenance is prioritized. Therefore, it is essential to perform exercises under the guidance of expert trainers and with proper technique to achieve effective results and avoid injuries (Sim *et al.* 2022).

In today's digital age, YouTube has become more than just a social media and entertainment platform; it has transformed into a tool for beneficial content creation and a large-scale information sharing and interaction medium (Aharul 2023; Di Virgilio and Das 2023). In this context, YouTube has become a highly preferred tool for reaching a wide audience in exercise and healthy living fields, particularly for popular exercise techniques like Reformer Pilates. The global reach of YouTube plays a significant role in the growing popularity of Reformer Pilates (McDonough *et al.* 2022). Content created by both professional and amateur trainers has raised awareness of this exercise technique by making the system and principles of Reformer Pilates easy to understand. However, the quality, reliability, and academic accuracy of these created contents have become a part of the general discussions about exercise content on YouTube (Ratwatte and Mattacola 2021; Sari *et al.* 2025).

The purpose of this study is to evaluate the accuracy and reliability of Reformer Pilates videos shared on YouTube, in addition to analyzing key viewer engagement metrics. By examining the

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visibility of Reformer Pilates on the platform, analyzing the diversity of content, the expertise and quality of the content creator, its popularity, and user interaction, the study seeks to reveal the impact of these videos on users and determine the role of YouTube in the widespread adoption of Reformer Pilates.

MATERIALS AND METHODS

Data Collection

On November 1, 2024, data for this analysis were sourced from YouTube, a widely used platform for video sharing and social networking. A search was performed using the term "Reformer Pilates" as the only keyword, and the resulting videos were sorted by their view counts, with the highest-ranked videos appearing first. The top 70 videos, all demonstrating Pilates exercises, were identified according to specific inclusion criteria. Videos were excluded if they were irrelevant, categorized as shorts, or were promotional in nature. Additionally, videos containing personal testimonials, those in languages other than English, those without sound, or those shorter than 25 seconds were also removed. The final dataset included videos with view counts ranging from over 2 million for the most watched to over 32 thousand for the least watched. Data from these videos were analyzed statistically. An instructor, accredited by the Turkish Gymnastics Federation, conducted the evaluation of each video. This evaluation process was based on standardized instruments, namely the Modified DISCERN (mDISCERN) scale, the Global Quality Scale (GQS), and the Journal of the American Medical Association (JAMA) scoring method Furthermore, metrics such as the view-to-like ratio and the Video Power Index (VPI) were computed from the available video data.

Evaluation Criteria

In this cross-sectional investigation, YouTube video reliability, quality, and popularity were assessed through various evaluation methods. The mDISCERN, GQS, and JAMA benchmarks were specifically used to ascertain the credibility and educational merit of the videos. Viewer engagement and popularity levels were gauged using the VPI.

The GQS, established by Bernard *et al.* (2007), is a five-point scale designed for evaluating the quality of medical video content intended to support patient education. It evaluates core elements such as scientific accuracy, clarity and effectiveness of communication, comprehensiveness, educational value, and the overall potential of the content to benefit viewers. Given the growing role of Reformer Pilates in rehabilitation, posture correction, pain management, and overall wellness, this scale was used to evaluate how effectively the videos present accurate and understandable information about Pilates exercises and their potential health benefits. Scores range from 1 (poor quality, useless/limited use to viewers) to 5 (excellent quality, highly beneficial/useful for viewers) (Bernard *et al.* 2007).

To assess the reliability and accuracy of content in the Reformer Pilates videos, the mDISCERN scale was utilized. This instrument, adapted by Singh *et al.* (2012) from the original DISCERN tool by Charnock *et al.* (1999), comprises five items. It evaluates dependability, clarity, effective presentation, and the capacity to deliver accurate health-related information. It was applied to examine whether the Reformer Pilates videos clearly define their purpose, provide balanced and evidence-based explanations of Reformer Pilates techniques, and address any benefits or limitations relevant to health outcomes. Each item receives a score of 1 (yes) or 0 (no), yielding a total score between 0 and 5, where higher scores denote superior informational quality (Singh *et al.* 2012; Charnock *et al.* 1999).

Evaluation of the Reformer Pilates videos' reliability and quality was conducted using the JAMA scale, a tool developed by Silberg *et al.* (1997). This scale examines essential components such as the accuracy of the information, scientific validity, clarity of expression, and the usefulness of the content for viewers.The four evaluation points—authorship (is it clear who is responsible for the content and their qualifications?), attribution (are sources for claims clearly cited?), disclosure (are conflicts of interest or sponsorships declared?), and currency (is the information up-to-date?)—were examined in the context of Reformer Pilates videos. Fulfillment of each criterion contributes one point to the score, leading to a possible range of 0 to 4, with higher scores signifying greater trustworthiness and reliability (Silberg *et al.* 1997).

Finally, the VPI, proposed by Erdem and Karaca (2018), was calculated to quantify viewer engagement and the popularity of Reformer Pilates videos. The VPI is used to determine the effectiveness of video content on social media platforms and to evaluate the extent of viewer interest it generates Given the growing interest in Reformer Pilates as both a fitness and rehabilitative practice, VPI quantified public interaction by incorporating metrics such as the likes and dislikes counts, total views, and the duration of time passed since each video was published (Erdem and Karaca 2018; Çoşkun and Demir 2024, 2025).

To perform the calculations, the following formulas were applied (Erdem and Karaca 2018; Çoşkun and Demir 2024).

$$VPI = \frac{\text{Like ratio} \times \text{View ratio}}{100}$$

$$\text{Like ratio} = \frac{100 \times \text{Like count}}{\text{Like count} + \text{Dislike count}}$$

$$\text{View ratio} = \frac{\text{View count}}{\text{Days since initial upload}}$$

Statistical Analyses

Analysis of the data was performed using SPSS software (Version 22.0, SPSS Inc., Chicago, IL, USA, License: Hitit University). For categorical variables, frequencies (n) and percentages (%) were used for description. Continuous data were summarized as mean $\pm$ standard deviation for those with a normal distribution, and as median (min–max) for non-normally distributed data. The assessment of data normality was carried out through the Shapiro–Wilk test along with graphical techniques. Since the data were not normally distributed, the Mann–Whitney U test was utilized for comparisons between two independent groups. The Kruskal–Wallis test was applied for comparisons across more than two independent groups when the assumptions of parametric tests were not satisfied. In cases of significant differences, pairwise post-hoc comparisons were conducted using the Dunn–Bonferroni test. Depending on the distributional features of the continuous variables, Spearman's correlation coefficient was employed to assess their associations. Statistical significance was set at $p < 0.05$.

Because the Video Power Index (VPI) is inherently skewed and heavy-tailed, mean-based regression models and variance-explained performance measures (e.g., R^2) were considered suboptimal. Therefore, a Quantile Regression Forest (QRF) approach was employed to estimate conditional quantiles of VPI and to identify predictors associated with high and very high viewer engagement. QRF is a non-parametric, tree-based machine learning method that extends random forests and is robust to nonlinear relationships, mixed predictor types, and non-normal error structures. The

outcome variable was VPI (continuous). Predictors included quality and reliability indicators (Global Quality Scale, modified DISCERN, and JAMA scores), video characteristics (video length and time since upload), and categorical descriptors related to content features and source characteristics (safety mention, publisher type, application location, instructor expertise, accessory use, machine settings demonstration, and region). The dataset was randomly divided into a training set (70%) and an independent test set (30%). All model selection and tuning procedures were conducted on the training set, with internal validation performed using 5-fold cross-validation. Model hyperparameters were optimized via randomized search using cross-validated pinball loss as the optimization criterion for $\tau = 0.75$ and $\tau = 0.90$. Model performance was evaluated using pinball loss, the standard metric for quantile regression models, with lower values indicating improved predictive accuracy. To enhance interpretability, quantile-specific permutation feature importance was computed by assessing changes in pinball loss following permutation of each predictor in the test set. All machine learning analyses were conducted using Python.

RESULTS

The first 70 videos featuring Reformer Pilates exercises were uploaded by individual YouTube channels (87.1%, n=61) and Pilates studio YouTube channels (12.9%, n=9). Of these videos, 55.7% (n=39) were filmed at home, while 44.3% (n=31) were filmed in a studio. It was found that 81.4% of the Pilates exercise videos did not specify the trainer's expertise, while 18.6% did indicate the trainer's expertise. The exercises targeted the following areas: 72.9% of the videos focused on the arms, 91.4% on the legs, 70% on the abdomen, 54.3% on the back, 77.1% on the hips, and 52.9% on the neck. The average video length was 1943.44 ± 1001.1 seconds, with video lengths ranging from 105 to 4234 seconds. The period since video upload ranged from 102 to 5507 days, averaging 1318 ± 1035.8 days. The number of views per video averaged 203335.4 ± 299235.8 (ranging from 32062 to 2003528), and the average number of likes was 2397.9 ± 2077.4 (ranging from 159 to 8828). The average Video Power Index (VPI) was 173.5 ± 193.1 (ranging from 22 to 1214.7). Additional descriptive statistics concerning the videos are detailed in Table 1.

The mean scores calculated for each evaluation tool were as follows: GQS, 3.06 ± 0.899; mDISCERN, 3.09 ± 1.073; and JAMA, 2.61 ± 1.09. The GQS assessment categorized 28.6% of the 70 analyzed videos as low quality, 45.7% as moderate quality, and 25.7% as high quality. Six videos achieved the maximum possible GQS score of 5. Eight videos attained a perfect score on the mDISCERN tool, and eighteen videos received a score of 4 on the JAMA criteria. Notably, a single video, which had garnered 77,000 views and was uploaded in 2020 by Homebody Pilates, achieved maximum scores across all three evaluation instruments; this video presented a studio-based Pilates routine targeting multiple body regions. The video with the highest view count (2003528 views), uploaded by VivaPilatesStudio, received scores of 4 for both GQS and mDISCERN, and 3 for JAMA. The second most viewed video (984,980 views) received scores of 4 for GQS, 3 for mDISCERN, and 3 for the JAMA criteria. The third and fourth most viewed videos (867220 and 683466 views) had scale scores of 3, 3, 4 and 3, 2, 2, respectively. The fifth most-viewed video (658421 views) scored 4 on GQS, 4 on mDISCERN, and 3 on JAMA.

Videos featuring expert trainers exhibited shorter durations, fewer views, lower VPI, and lower JAMA scores relative to those by non-expert trainers; however, these observed differences did not reach statistical significance (P-values: 0.862, 0.294, 0.886, and 0.324, respectively; see Table 2). Conversely, expert trainer videos showed higher GQS scores than those without expert trainers, though this difference also lacked statistical significance (P-value: 0.809; Table 2). Videos by expert trainers had statistically significantly lower mDISCERN scores than those by non-expert trainers (P-value: 0.005; see Table 2). A jittered boxplot illustrating the distribution of GQS, mDISCERN, JAMA, and VPI scores across different instructor expertise levels is presented in Figure 1A.

Videos recorded in studios tended to have higher views, VPI, GQS, mDISCERN, and JAMA scores than home-filmed videos, yet none of these differences were statistically significant (P-values: 0.274, 0.411, 0.098, 0.820, and 0.257, respectively; see Table 2). The length of studio-filmed videos was shorter than that of home-filmed videos, but this difference was not statistically significant (P-value: 0.290; see Table 2). A jittered boxplot depicting the distribution of GQS, mDISCERN, JAMA, and VPI scores across different pilates location categories is presented in Figure 1B.

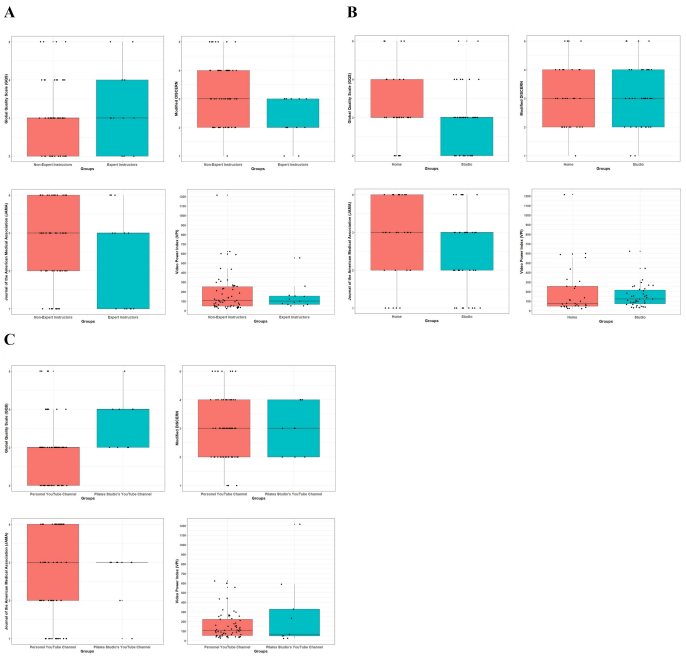

Figure 1 Distribution of quality, reliability, and engagement metrics across video characteristics. (A) Boxplot with jitter illustrating the distribution of Global Quality Scale (GQS), modified DISCERN (mDISCERN), Journal of the American Medical Association (JAMA), and Video Power Index (VPI) scores across different instructor expertise. (B) Boxplot with jitter illustrating the distribution of Global Quality Scale (GQS), modified DISCERN (mDISCERN), Journal of the American Medical Association (JAMA), and Video Power Index (VPI) scores across different pilates locations. (C) Boxplot with jitter illustrating the distribution of Global Quality Scale (GQS), modified DISCERN (mDISCERN), Journal of the American Medical Association (JAMA), and Video Power Index (VPI) scores among different video publishers.

Content from Pilates studio YouTube channels demonstrated higher view counts and JAMA scores when compared to videos from personal YouTube channels, though these distinctions were not statistically significant (P-values: 0.101, and 0.971, respectively; see Table 3). Additionally, Pilates studio YouTube channel videos had lower VPI and mDISCERN scores compared to personal YouTube channel videos, but these differences were not

Table 1 Descriptive statistical findings regarding the characteristics of the analysed YouTube videos (n=70)

	n	%		Mean ± SD	Median (min–max)
Video publisher			**Video features**		
Personal YouTube Channel	61	87.1	Video length (seconds)	1943.44 ± 1001.1	2077.5 (105–4234)
Pilates studio's YouTube channel	9	12.9	Time since upload (days)	1318 ± 1035.8	1077.5 (102–5507)
Pilates application location			Number of views	203335.4 ± 299235.8	94415.5 (32062–2003528)
Home	39	55.7	Number of likes	2397.9 ± 2077.4	1591 (159–8828)
Studio	31	44.3	Number of dislikes	46.81 ± 76.99	19.5 (0–510)
Instructor expertise			Comments	107.8 ± 143.4	76.5 (1–1018)
No	57	81.4	View ratio	177.8 ± 200.2	108.5 (23.3–1283.5)
Yes	13	18.6	Like ratio	97.9 ± 2.52	98.6 (87.8–100)
Activated regions			VPI	173.5 ± 193.1	106.2 (22–1214.7)
Arm			**Scales**		
No	19	27.1	GQS	3.06 ± 0.899	3 (2–5)
Yes	51	72.9	Modified DISCERN	3.09 ± 1.073	3 (1–5)
Leg			JAMA	2.61 ± 1.09	3 (1–4)
No	6	8.6			
Yes	64	91.4			
Abdomen					
No	21	30.0			
Yes	49	70.0			
Back					
No	32	45.7			
Yes	38	54.3			
Hips					
No	16	22.9			
Yes	54	77.1			
Neck					
No	33	47.1			
Yes	37	52.9			
Region					
Single region	5	7.1			
Multiple regions	65	92.9			
Is the activated region specified?					
No	25	35.7			
Yes	45	64.3			
Are the machine settings demonstrated?					
No	23	32.9			
Yes	47	67.1			
Is there use of additional accessories?					
No	42	60.0			
Yes	28	40.0			
Is safety mentioned?					
No	54	77.1			
Yes	16	22.9			
Content type					
Theoretical knowledge	5	7.1			
Application	18	25.7			
Mixed	47	67.1			

VPI: Video Power Index; JAMA: Journal of the American Medical Association; GQS: global quality scale

Table 2 Statistical findings comparing video length, number of views, VPI, GQS, Modified DISCERN, and JAMA scores among groups categorized by instructor expertise and reformer Pilates application location.

	Instructional Expertise			Location		
	No (n=57)	**Yes (n=13)**	***P* values**	**Studio (n=31)**	**Home (n=39)**	***P* values**
Video length (seconds)	2082 (105–3425) 1948.6±980.5	1812 (148–4234) 1920.5±1129.47	0.862	1812 (105–4234) 1793.6±1151.2	2198 (148–3425) 2062.5±860.7	0.290
Number of views	78787 (32062–2003528) 211461.5±325237.8	123615 (37141–575970) 167705.5±139785.3	0.294	110952 (32916–2003528) 264331.8±402417.6	88503 (32062–867220) 154851.1±171156.4	0.274
VPI	108.9 (22–1214.7) 179.8±204.3	100.4 (50.1–555.8) 145.9±136.2	0.886	74.8 (22–1214.7) 196.02±256.8	122 (30.9–622.6) 155.6±122.1	0.411
GQS	3 (2–5) 3.04±0.865	3 (2–5) 3.15±1.068	0.809	3 (2–5) 3.26±0.930	3 (2–5) 2.9±0.852	0.098
Modified DISCERN	3 (1–5) 3.26±1.061	2 (1–3) 2.31±0.751	**0.005**	3 (1–5) 3.13±1.118	3 (1–5) 3.05±1.05	0.820
JAMA	3 (1–4) 2.68±1.038	3 (1–4) 2.31±1.316	0.324	3 (1–4) 2.77±1.117	3 (1–4) 2.49±1.073	0.257

Mann Whitney U test with median (min–max) and mean ± SD
VPI: Video Power Index, GQS: Global Quality Scale, JAMA: Journal of the American Medical Association

statistically significant (P-values: 0.951, and 0.848, respectively; see Table 3). However, Pilates studio YouTube channel videos had statistically significantly higher GQS scores compared to personal YouTube channel videos (P-value: 0.016; see Table 3). Videos from Pilates studio channels were statistically significantly shorter in length than those from personal channels (P-value: 0.043; see Table 3). A jittered boxplot illustrating the distribution of GQS, mDISCERN, JAMA, and VPI scores across different video publishers is presented in Figure 1C.

Correlation analysis revealed no statistically significant relationships between GQS, Modified DISCERN, or JAMA scores and time since video upload, video length, number of views, number of likes, or VPI (all $P > 0.05$; see Table 4). Nevertheless, a weak positive correlation was observed between time since upload and number of views ($r = 0.466$, $P < 0.001$), whereas weak negative correlations were identified between time since upload and VPI ($r = -0.298$, $P = 0.012$) and between video length and number of views ($r = -0.308$, $P = 0.009$). No other statistically significant relationships were detected (all $P > 0.05$; Table 4).

Given the heavy-tailed and highly skewed distribution of the Video Power Index (VPI), Quantile Regression Forest (QRF) analysis was performed to model high and very high levels of viewer engagement. Model performance was evaluated using the pinball loss function, which provides quantile-specific predictive accuracy without reliance on variance-explained measures. Using a 70/30 train–test split with internal 5-fold cross-validation on the training set, the QRF model demonstrated stable and consistent performance across quantiles. For high engagement ($\tau = 0.75$), the mean pinball loss during cross-validation was 66.96 ± 36.95, while the corresponding pinball loss in the independent test set was 53.22. For very high engagement ($\tau = 0.90$), model performance improved, with a cross-validated pinball loss of 54.06 ± 35.73 and a lower pinball loss of 35.80 in the test set (Table 5).

Quantile-specific permutation feature importance analysis was conducted to improve interpretability of the model. Feature importance profiles differed across quantiles, indicating heterogeneity in the factors associated with viewer engagement at different levels of VPI. At the high engagement level ($\tau = 0.75$), time since upload was the most influential predictor, followed by overall content quality, as measured by the Global Quality Scale (GQS). Video duration also contributed notably, with longer videos associated with lower engagement, while explicit mention of safety information and publisher type showed additional influence (Figure 2).

At the very high engagement level ($\tau = 0.90$), time since upload remained the dominant predictor; however, indicators related to professional credibility, particularly publisher type, gained relative importance. GQS continued to contribute meaningfully, and video duration retained a negative association with engagement, even among the most highly viewed videos (Figure 3). Across both upper quantiles, time since upload, GQS, video duration, safety mention, and publisher type were consistently ranked among the most influential predictors of viewer engagement.

Table 3 Statistical findings comparing video length, number of views, VPI, GQS, Modified DISCERN, and JAMA scores among groups created based on video publisher

	Video Publisher		
	Personal YouTube Channel (n=61)	**Pilates Studio's YouTube Channel (n=9)**	***P* values**
Video length (seconds)	2132 (105–4234) 2039.1±971.09	1210 (192–2920) 1294.6±1014.4	**0.043**
Number of views	88503 (32062–867220) 154882.5±168284.6	211989 (36628–2003528) 531738.4±648592.4	0.101
VPI	108.9 (26.10–622.60) 156.7±140.5	65.8 (22–1214.7) 287.05±396.1	0.951
GQS	3 (2–5) 2.97±0.894	4 (3–5) 3.67±0.707	**0.016**
Modified DISCERN	3 (1–5) 3.1±1.106	3 (2–4) 3±0.866	0.848
JAMA	3 (1–4) 2.61±1.144	3 (1–3) 2.67±0.707	0.971

Mann Whitney U test with median (min–max) and mean ± SD
VPI: Video Power Index, GQS: Global Quality Scale, JAMA: Journal of the American Medical Association

Table 4 Correlation analysis findings determining the relationships between video metrics and GQS, Modified DISCERN, and JAMA scale scores, along with the relationships between video characteristics and video metrics (n=70)

		GQS	**Modified DISCERN**	**JAMA**
Time since upload (days)	*r*	0.114	-0.209	0.055
	P	0.349	0.083	0.649
Video length (seconds)	*r*	0.078	-0.094	0.019
	P	0.521	0.437	0.875
Number of views	*r*	0.195	-0.029	-0.036
	P	0.105	0.814	0.767
Number of likes	*r*	0.047	0.038	-0.008
	P	0.701	0.753	0.949
VPI	*r*	0.105	0.185	-0.078
	P	0.386	0.126	0.520
Correlation between video characteristics and video metrics				
		Time since upload (days)	**Video length (seconds)**	
Number of views	*r*	**0.466****	**-0.308****	
	P	< 0.001	0.009	
Number of likes	*r*	0.169	-0.017	
	P	0.161	0.889	
VPI	*r*	**-0.298***	-0.128	
	P	0.012	0.289	

GQS: Global Quality Scale; JAMA: Journal of the American Medical Association; VPI: Video Power Index

DISCUSSION

The findings of this study reveal several key factors influencing the popularity, perceived quality, and characteristics of Reformer Pilates videos on YouTube. In particular, Quantile Regression Forest analysis focusing on high and very high engagement levels

Table 5 Quantile Regression Forest performance for predicting Video Power Index (VPI)

Quantile (τ)	Evaluation Strategy	Pinball Loss (Mean $\pm$ SD)
0.75	5-fold CV (training set, 70%)	66.96 ± 36.95
0.75	Hold-out Test Set (30%)	53.22
0.90	5-fold CV (training set, 70%)	54.06 ± 35.73
0.90	Hold-out Test Set (30%)	35.80

Abbreviations: Pinball loss: quantile-specific loss function (lower values indicate better predictive accuracy); VPI: Video Power Index; CV: cross-validation.

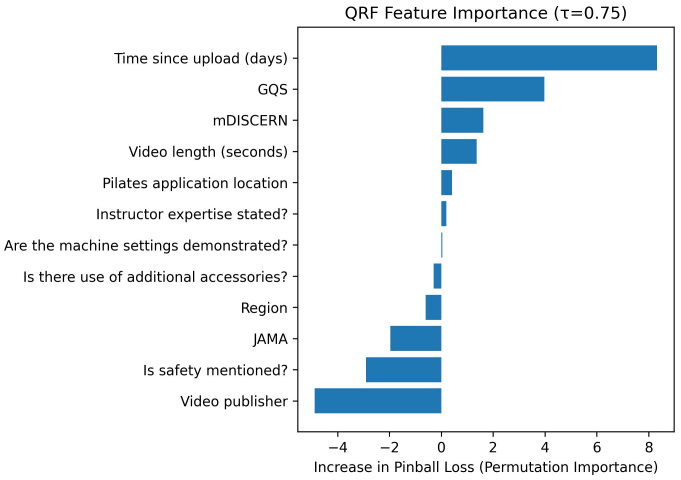

Figure 2 Feature importance at high engagement level ($\tau = 0.75$). *Footnote:* Permutation-based feature importance for the Quantile Regression Forest model. Importance values represent the increase in pinball loss following permutation of each predictor.

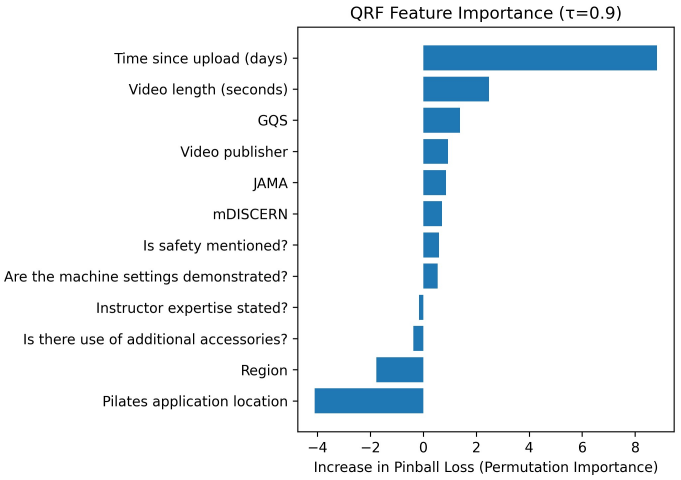

Figure 3 Feature importance at very high engagement level ($\tau = 0.90$). *Footnote:* Permutation-based feature importance for the Quantile Regression Forest model at the very high engagement quantile ($\tau = 0.90$). Importance values represent the increase in pinball loss following permutation of each predictor.

indicated that specific content-related features are associated with higher viewer engagement, with explicit mention of safety information emerging as one of the influential predictors of the Video Power Index (VPI). This indicates that viewers, likely including a significant proportion of beginners or those less familiar with the specialized equipment, prioritize safety when engaging with exercises like Reformer Pilates, which inherently involve technical skill and potential injury risk. The explicit emphasis on safety appears to foster trust and drive engagement. This result is in line with the study by Ratwatte and Mattacola (2021), which suggested that safety warnings in fitness content enhance viewer trust and positively affect engagement. The importance of clear, actionable safety information in online exercise content cannot be overstated, especially given the autonomous nature of at-home exercise guided by such videos Gronwald *et al.* (2022), while focusing on hamstring injuries in football, highlight the general need for demand-specific risk reduction, a principle applicable to online exercise guidance).

Time since upload was identified as the most influential predictor of viewer engagement in the Quantile Regression Forest analysis at both high and very high engagement levels. This finding reflects the "content decay" phenomenon, in which older videos gradually lose visibility and relative popularity as platforms and viewers prioritize newer content. This can be explained by social media algorithms prioritizing new content and viewers' tendency to engage with new videos. Supporting this trend, Di Virgilio and Das (2023) noted that social media platforms highlight continuously updated content, causing older videos to lose visibility. While older videos accumulate more total views over time (as shown by the weak positive correlation between time since upload and views), their power to engage relative to newer content diminishes. This necessitates a strategy of regular content creation or strategic re-promotion of older, high-quality content for creators aiming for sustained impact on platforms driven by novelty and recency.

Video duration was identified as an influential predictor of viewer engagement in the Quantile Regression Forest analysis at both high and very high engagement levels. Longer videos were consistently associated with lower engagement, indicating that shorter and more concise content is more effective in achieving higher Video Power Index (VPI) values. This finding is consistent with McDonough *et al.* (2022), who found that shorter, goal-oriented content in exercise programs on YouTube receives higher engagement. The average video length in our sample was substantial (1943.44 ± 1001.1 seconds), suggesting that many videos may exceed the optimal duration for viewer attention and engagement in the current digital landscape, which often favors "snackable" content. Interestingly, our finding that videos from Pilates studio channels were statistically significantly shorter in length than those from personal channels might indicate that professional studios are more attuned to this preference for brevity or are structuring content in more digestible segments.

Overall content quality, as measured by the Global Quality Scale (GQS), consistently ranked among the influential predictors of viewer engagement in the Quantile Regression Forest analysis at both high and very high engagement levels. This finding suggests that higher-quality instructional content is more strongly represented among videos achieving elevated engagement levels. The GQS scale, developed by Bernard *et al.* (2007), is a recognized tool for assessing video quality. Our results align with Erdem and Karaca (2018), who found that channels producing high-quality content on YouTube received more engagement in their study of kyphosis exercise videos.

Furthermore, videos published by Pilates studio channels exhibited higher GQS scores compared with personal channels, suggesting that professionally produced content may be associated with higher perceived quality. Given that GQS consistently ranked among the influential predictors of engagement in the Quantile Regression Forest analysis, this finding supports the relevance of professional production standards in achieving higher viewer engagement. The average GQS score for the analyzed videos was 3.06 ± 0.899, with 45.7% rated as medium quality and only 25.7% as high quality, indicating substantial room for improvement in the overall quality of Reformer Pilates content on YouTube. The potential for video analysis to assess and improve movement quality, as demonstrated in various contexts from running gait (Vergeer *et al.* 2023) to specific exercises like back squats (Peres *et al.* 2024), underscores the value of high-quality visual presentation in exercise videos.

An unexpected finding of this study was that videos featuring trainers who explicitly stated their expertise tended to receive lower Modified DISCERN scores compared with videos presented by trainers without stated expertise. The Modified DISCERN tool assesses reliability and content accuracy, particularly the clarity and effective presentation of health-related information (Singh *et al.* 2012; Charnock *et al.* 1999). This counterintuitive result does not necessarily imply that expert trainers provide less reliable information, but rather, as Singh *et al.* (2012) highlighted, the presentation of content, particularly the excessive use of technical terms, can reduce viewer comprehension. With 81.4% of videos not specifying trainer expertise, those that did might have fallen into the trap of using overly technical language, thereby diminishing clarity and accessibility for a general audience, which is reflected in lower DISCERN scores. This underscores the critical importance for expert trainers to employ clear, simple, and understandable language when conveying information to a broad audience on platforms like YouTube, ensuring their expertise translates into accessible and truly informative content. While methods like 2D video analysis are increasingly used to evaluate exercise form and ROM (Tanioka *et al.* 2022), the verbal communication accompanying these visuals is equally crucial for the viewer's understanding and perceived quality.

Regarding filming location, videos filmed in studios had descriptively higher views, VPI, GQS, mDISCERN, and JAMA scores compared to those filmed at home. However, these differences were not statistically significant, although studio-filmed videos tended to exhibit higher GQS scores. This suggests that while professional settings can contribute to higher production quality, high-quality content can also be produced in home settings with appropriate equipment and planning. The lack of statistical significance may also be due to the relatively small number of studio channel videos (n=9) in our sample. The ability of platforms like YouTube to host content from diverse creators, regardless of access to professional studios, is a key aspect of its democratizing influence on information dissemination.

Overall, these findings provide valuable insights into how Reformer Pilates videos are perceived by their audience and which content features enhance engagement. The average quality scores (GQS 3.06, Modified DISCERN 3.09, JAMA 2.61) indicate a general landscape of moderate quality, highlighting a significant opportunity for content creators to improve. Creators can increase their success on digital platforms by producing content that emphasizes safety, is concise and up-to-date, is of high overall quality, and communicates expertise in an accessible manner.

Limitations

This study encountered some methodological limitations while evaluating Reformer Pilates content on YouTube. Due to the study design, the analysis was limited to the 70 most-watched English-language videos at a specific point in time (November 1, 2024). This limitation may affect the generalizability of the findings, as the dynamic nature of the platform and algorithmic changes can influence content visibility over time. Despite these limitations, the study provides a robust methodological framework for evaluating digital exercise content and lays an important foundation for future research. In particular, it paves the way for multicenter and longitudinal studies that encompass content produced across different cultures and languages. Furthermore, the findings offer practical value by providing concrete recommendations for content creators to enhance the quality and engagement potential of their videos.

CONCLUSION

The results of this study reveal factors influencing the popularity of Reformer Pilates videos, offering important insights for digital exercise content creators. The findings suggest that videos that include safety information, are of high quality, short in duration, and up to date are more likely to be associated with higher viewer engagement. The observed association between video quality, content reliability, and viewer interaction highlights the importance for content creators to consider professionalism and clarity when developing educational materials. Furthermore, the observed decline in engagement of older videos over time underscores the critical need for consistent production of updated content to maintain visibility on digital platforms. It has been observed that technical language in content created by expert trainers can sometimes reduce comprehensibility, negatively affecting the informative quality. Therefore, it is recommended that content be prepared to maintain scientific accuracy while using clear and accessible language. Based on the data obtained, effective presentation of exercise content such as Reformer Pilates on digital platforms is more likely when videos emphasize safety, are high quality, concise, and up to date. This approach will enhance both viewer satisfaction and the level of information provided. The findings of this study highlight the need to evaluate Reformer Pilates content on YouTube not only based on view counts but also in terms of content quality and relevance.

Ethical standard

The authors have no relevant financial or non-financial interests to disclose.

Availability of data and material

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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