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# The negative impact of anterior cruciate ligament reconstruction in professional male footballers

Kathryn A. Barth [a], Cort D. Lawton [a,*], Daniel C. Touhey [a], Ryan S. Selley [a], Daniel D. Li [a], Earvin S. Balderama [b], Gordon W. Nuber [a], Wellington K. Hsu [a]

[a] Northwestern Memorial Hospital, Department of Orthopedic Surgery, 676 North St. Clair St., Suite 1350, Chicago, IL, 60661, USA
[b] Loyola University Chicago, Department of Mathematics and Statistics, 1032 West Sheridan Road, Chicago, IL, 60660, USA

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ABSTRACT

*Background:* Soccer is one of the most common international sports in which ACL injuries occur, with previous studies reporting high return-to-play rates following ACL reconstruction (ACLR). Return-to-play analysis fails to take into consideration how effective a player remains once returning to competition. The aims of this study are to provide a large-scale international analysis of return-to-play and player performance statistics among professional soccer athletes following ACLR.

*Methods:* Using publicly available sources, professional soccer athletes who have undergone ACLR between the 1996 and 2015 seasons were identified. Player metrics including statistical performance, recovery time, and return-to-play rates were analyzed both before and after reconstruction. Furthermore, player performance statistics during each of three consecutive seasons post-ACLR were compared.

*Results:* A total of 176 athletes who underwent ACLR were included in this study. The return-to-play rate was 93.2% (164 athletes). Cumulative post-surgical statistical analysis of ACLR players demonstrated fewer games/season, minutes/season, minutes/game, goals/season, and more fouls/season following ACLR ($p < 0.04$). Analysis of player performance statistics suggests that athletes do not return to their baseline number of games/season and minutes/game until two and three seasons post-ACLR, respectively. At three seasons post-ACLR, athletes are still starting fewer games/season and scoring fewer goals/90 min ($p < 0.04$).

*Conclusion:* Return-to-play rate is high following ACLR; however, athletes exhibit poorer statistical performance, especially in the first few seasons upon return. Our data shows that athletes continue to start fewer games/season and score fewer goals/90 min at three seasons post-ACLR.


## 1. Introduction

Anterior cruciate ligament (ACL) ruptures are one of the most common knee injuries in athletes during both contact and non-contact sports [1–5]. A majority of ACL tears result from a noncontact injury, usually involving cutting, jumping, or pivoting [6]. Football not only routinely utilizes these movements, but also is the most popular sport worldwide, leading to a high prevalence of these injuries [1,7,8]. While the Multicenter Orthopedic Outcomes Network (MOON) has reported that football is the second most common sport associated with ACL injury in the United States, the Norwegian National Knee Ligament Registry (NKLR) in-

* Corresponding author at: Northwestern Memorial Hospital, Department of Orthopedic Surgery, 676 North Saint Clair, Chicago, IL 60611.
*E-mail address:* cort.lawton125@gmail.com. (C.D. Lawton).

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dicates the sport as being the most common [7,9]. The United Kingdom National Ligament Registry 2017 report found 46.7% of ACL injuries occurred while playing football, a much higher percentage than what was seen in other sports.

Knee injuries occur at a higher rate in professional athletes compared to the general population, with an overall incidence of ACL injury among professional athletes ranging from 0.15%–3.7% [10,11]. The integrity of the ACL is vital to planting, cutting, pivoting and jumping, with different sports requiring different demands placed on a repaired ACL. Mai et al. analyzed performance-based outcomes in professional athletes across four different sports, showing differences in outcomes between sports [12]. This data highlights how the intricacies of different sports place different physical demands on an ACL reconstruction (ACLR), suggesting that an ACLR may be more or less detrimental to an athlete's career depending on the sport they participate in.

Previous studies have reported high rates of return-to-play (RTP) following ACLR among European professional footballers, though, it is still unknown how surgical treatment affects player performance statistics [13–15]. Small case series exist reporting player performance in professional footballers, however, these sample sizes have limited definitive conclusions [16]. Further data on professional footballers following ACLR is required to determine how these injuries affect player performance. We sought to provide the largest analysis of RTP and performance-based outcomes among professional footballers following ACLR to date. Such data not only guides post-operative expectations for athletes and team physicians, but also highlights relative differences in recovery time, clinical outcomes, and performance depending on sport played.

## 2. Materials and methods

Using a methodology based on a previously established protocol, professional footballers in professional leagues that have undergone ACLR between the 1996 and 2015 seasons were identified using publicly available injury reports, newspaper articles, journals, and blog archives [17,18]. Search terms used to identify potential injuries included combinations of “ACL”, “anterior cruciate ligament”, “cruciate ligament”, “injury”, “surgery”, “reconstruction”, “English Premier League”, “Major League Soccer”, “La Liga”, “Spanish La Liga”, “German Bundesliga”, “Bundesliga”, “French Ligue”, “Ligue”, “Italian Serie”, and “Serie”. The athletes' ACL reconstructions were further confirmed through two independent sources and injury dates, surgery dates, and laterality were collected. Inclusion criteria were professional footballers with virgin ACLR during their active career with a confirmed surgery date. Because the leagues with the greatest amount of available data were in the United States and Europe, players who were members of one of six professional football leagues were searched (Major League soccer [MLS; United States], English Premier League/Championship League [EPL/CL; England], Bundesliga [Germany], La Liga [Spain], Serie [Italy], Ligue [France]). Athletes were excluded if injury reports or dates were conflicting, or the player had an ACLR prior to their professional career.

Athlete demographic data and baseline statistical information was collected from a publically available source that compiles all professional football league activity (www.ESPN.com). Data collected included date of RTP, career length, and detailed cumulative pre- and post-injury player performance statistics. Successful RTP was defined as an athlete who played in a minimum of one professional game in any league following the injury. Specific player performance statistics collected included seasons played, games, starts, minutes, goals, assists, shots on goals, saves, goals conceded, shut outs, yellow cards, red cards, and fouls committed. Data collected specific to defenders and goalkeepers included goals conceded and shutouts. Saves were collected for goalkeepers only.

**Table 1**
Athlete demographics.

| Variable | Value |
|---|---|
| Number ACLR athletes | 176 |
| Mean age at date of injury | 26.1 ± 3.8 |
| Mean BMI | 23.7 ± 2.4 |
| Laterality of ACLR (n = 176) | |
| Right | 84 |
| Left | 59 |
| Unreported | 33 |
| Athletes by position (n = 176) | |
| Midfield | 73 |
| Forward | 54 |
| Defender | 41 |
| Goalkeeper | 8 |
| Athletes by league (n = 176) | |
| United States MLS | 50 |
| EPL/CL | 88 |
| Spanish La Liga | 11 |
| German Bundesliga | 14 |
| French Ligue | 2 |
| Italian Serie | 11 |

Abbreviations: ACLR — anterior cruciate ligament reconstruction; BMI — body mass index; MLS — Major League Soccer; EPL/CL — English Premier League/Championship League.

Statistical performance was compiled for individual seasons including one season prior to injury (index season) as well as the first, second, and third seasons following ACLR. A complete season was defined as game participation/availability for at least one half of an eight-month season, or four months. The index season was defined as the first season prior to surgery with a minimum of four months of competition. For athletes with injuries sustained early in the season (less than four months into competition), the season prior to the injury was designated the index season. Similarly, the first season following ACLR was defined as the first season with a minimum of four months of competition. The second and third seasons post-ACLR represent the seasons following the first season post-ACLR regardless of the amount of time played.

Subsequent ACL tears were identified and documented for all athletes who returned to play following initial ACLR. The time to ipsilateral recurrent tear or contralateral tear was calculated from the day of the initial ACLR surgery. Cumulative player performance statistics of this cohort were analyzed separately. Data for the typical roster distribution, as depicted in Table 2, was determined from assessment of 2018 rosters from teams within leagues included in this study.

All descriptive and inferential statistics were completed using the program R version 3.3.2 (The R Foundation for Statistical Computing, https://www.r-project.org/). A two-tailed matched paired sample *t*-test was used for comparing quantitative performance measures pre- and post-ACLR. The assumptions for the matched paired *t*-test were satisfied including normal distribution of the observations.

## 3. Results

A total of 176 professional footballers met inclusion criteria with a mean age at the date of injury of 26.1 ± 3.8 years. The most common position of the ACLR athletes included in this study was midfield, followed by forward, defender, and goalkeeper (Table 1). A total of 164 athletes (93.2%) successfully returned to play in an international competition. After controlling for a typical roster distribution, forwards underwent ACLR more frequently than expected, contrary to that seen in defenders and goalkeepers (Table 2). Athletes had surgical reconstruction 13.7 ± 1.0 days following ACL tear and returned to play 310.9 ± 14.9 days after ACLR (Table 3).

Over the length of an athletes' career, players who underwent ACLR played significantly more seasons prior to injury compared to post-ACLR (p-value <0.01). Following ACLR, statistical performance significantly decreased for games/season (p-value = 0.04), minutes/season (p-value <0.01), and minutes/game (p-value <0.01). Furthermore, goals/season significantly declined pre- to post-ACLR (p-value <0.01). Conversely, players committed significantly more fouls/season following ACLR (p-value = 0.04) (Table 4).

Athletes played significantly fewer games in the first season post-ACLR compared to the index season (p-value <0.01), but returned to baseline during post-ACLR years two and three (p-value 0.94 and p-value 0.76, respectively). Similarly, minutes/game decreased significantly after surgery from the index season compared to post-ACLR seasons one and two (p-value <0.01). At three seasons post-ACLR, minutes/game returned to baseline (p-value = 0.28). Percentage of games started (p-value <0.05) and goals/90 min of play (p-value <0.03) significantly decreased in all seasons after ACLR when compared to the index season. Players committed more fouls at post-ACLR seasons one and two (p-value <0.01), with return to their baseline three seasons post-ACLR (p-value = 0.06) (Table 5 and Figure 1).

A total of 26 players (15.9%) suffered subsequent ACL tears at a mean of 525.7 ± 82.6 days after their initial reconstruction. Nineteen players (11.6%) sustained an ipsilateral recurrent tear, while seven players (4.3%) sustained a contralateral tear. The return-to-play rate following a second ACLR was 88.5% at a mean time of 324.4 ± 27.8 days (Table 3). There was no significant difference in mean cumulative player performance statistics when comparing performance during the seasons between their two ACL reconstructions and the seasons after their second ACLR.

## 4. Discussion

Football has been the most common sport associated with ACL tear in the Norwegian National Knee Ligament Registry (NKLR) and the second most common sport in the Multicenter Orthopedic Outcomes Network (MOON) database [7,9]. Furthermore, the United Kingdom National Ligament Registry 2017 report found 46.7% of ACL injuries occurred while playing football, which was a much higher percentage than what was seen in any other sports. Recovery from this injury may vary depending on sport played.

**Table 2**
Anterior cruciate ligament reconstruction by position.

| Position | Number of ACLR athletes | Percent of total ACLR athletes | Typical roster distribution | Percent of total roster |
|---|---|---|---|---|
| Midfield | 73 | 41.5% | 11 | 36.7% |
| Forward* | 54 | 30.7% | 5 | 16.7% |
| Defender** | 41 | 23.3% | 11 | 36.7% |
| Goalkeeper** | 8 | 4.6% | 3 | 10.0% |

Abbreviations: ACLR — anterior cruciate ligament reconstruction.
Chi-squared <0.01.
* Significantly more forwards required ACLR than expected (p-value <0.05).
** Significantly fewer defenders and goalkeepers required ACLR than expected (p-value <0.05).

**Table 3**
Return-to-play analysis.

| Variable | Value |
|---|---|
| Number of ACLR athletes | 176 |
| Return-to-play rate (number of athletes) | 93.2% (164) |
| Mean time (in days) to surgery | 13.7 ± 1.0 |
| Mean time (in days) to return-to-play | 310.9 ± 14.9 |
| All athletes suffering 2nd ACL tears (% of athletes who returned to play) | 26 (15.9%) |
| Mean time (in days) to subsequent tear | 525.7 ± 82.6 |
| Return-to-play rate after subsequent tear (number of athletes) | 88.5% (23) |
| Mean age at date of subsequent tear | 26.4 ± 0.7 |
| Mean time (in days) to return-to-play after subsequent tear | 324.4 ± 27.8 |
| Ipsilateral recurrent tears (% of athletes who returned to play) | 19 (11.6%) |
| Mean time (in days) to recurrent tear | 425.0 ± 82.0 |
| Return-to-play rate after recurrent tear (number of athletes) | 84.2% (16) |
| Mean time (in days) to return-to-play after recurrent tear | 350.3 ± 37.5 |
| Contralateral tears (% of athletes who returned to play) | 7 (4.3%) |
| Mean time (in days) to recurrent tear | 799.0 ± 183.4 |
| Return to play rate after contralateral tear (number of athletes) | 100% (7) |
| Mean time (in days) to return-to-play after contralateral tear | 265.3 ± 21.1 |

Abbreviations: ACLR — anterior cruciate ligament reconstruction; ACL — anterior cruciate ligament.

Mai et al. showed that return-to-play rates, change in games played, and change in player performance pre- and post-ACLR as professional athletes varied depending on an athletes sport [12].

A few studies have reported RTP rates following ACLR among various cohorts of footballers; however, these lack analysis of player performance statistics following RTP [8,9,13,15,19]. While RTP rates for recreational athletes are low (28–49%) [9,19–21], higher rates are seen in professional football cohorts (77%–95%) [13,15,16]. We believe RTP analysis alone fails to assess how effective a player remains once returning to competition, resulting in an over estimation of the success of various surgical procedures in professional athletes. Furthermore, RTP lacks assessment of an injuries long-term effect on a player's performance. It has been unknown what the effects of ACLR are to a professional footballers performance. Such studies are vital to advance our understanding of the impact various surgical procedures have on an athlete's career, and allow for continued evolution of surgical techniques and rehabilitation protocols to improve long-term outcomes in these athletes.

The data in this study suggests that professional footballers RTP at a high rate (93.2%) with a reasonable recovery time (310.9 ± 14.9 days). Statistical performance in the virgin ACLR cohort significantly declined in a number of categories post-operatively. For example, athletes played in significantly fewer games/season, minutes/season, minutes/game, scored fewer goals/season, and committed more fouls/season when comparing mean cumulative player performance statistics pre- and post-ACLR. These metrics indicate that ACLR falls short of returning a player back to baseline status. For the position of defender, the number of committed fouls may be a more accurate metric than goals scored. The fact that this metric increased after ACLR suggests that players may be less adept at defending attacking players and establishing field position. These findings are contrary to that

**Table 4**
Cumulative player performance statistics pre- and post-ACLR.

| Performance statistic | Pre-ACLR mean[a] | Post-ACLR mean | p-Value[b] |
|---|---|---|---|
| Seasons played | 5.5 ± 0.2 | 4.0 ± 0.3 | <0.01* |
| Games per season | 23.7 ± 0.9 | 22.5 ± 0.9 | 0.04* |
| Starts per season | 19.2 ± 0.8 | 18.3 ± 1.7 | 0.32 |
| Minutes per season | 1718.4 ± 67.8 | 1525.7 ± 78.1 | <0.01* |
| Minutes per game | 70.5 ± 1.3 | 63.6 ± 1.6 | <0.01* |
| Goals per season | 4.1 ± 0.4 | 2.9 ± 0.3 | <0.01* |
| Shots per season | 21.0 ± 1.7 | 22.4 ± 2.0 | 0.65 |
| Shots on goal per season | 9.6 ± 0.8 | 8.9 ± 0.8 | 0.26 |
| Assists per season | 1.5 ± 0.1 | 1.6 ± 0.2 | 0.74 |
| Goals conceded per season | 25.1 ± 1.5 | 27.0 ± 2.1 | 0.71 |
| Shutouts per season | 7.1 ± 0.6 | 6.6 ± 0.7 | 0.24 |
| Saves per season | 53.1 ± 4.8 | 68.9 ± 18.7 | 0.52 |
| Fouls committed per season | 16.3 ± 1.2 | 20.0 ± 1.5 | 0.04* |
| Yellow cards per season | 3.3 ± 0.2 | 3.0 ± 0.2 | 0.09 |
| Red cards per season | 0.2 ± 0.03 | 0.2 ± 0.03 | 0.91 |

Abbreviations: ACLR — anterior cruciate ligament reconstruction.
[a] Values are given in the form of mean ± standard error.
[b] p-value <0.05 were considered statistically significant.
* Represents statistically significant difference (p-value <0.05).

**Table 5**
Player performance statistics by season.

| Performance statistic | Index season[a] | 1 season post-ACLR | p-Value[b] | 2 seasons post-ACLR | p-value | 3 seasons post-ACLR | p-Value |
|---|---|---|---|---|---|---|---|
| Games Played | 26.8 ± 1.1 | 21.3 ± 1.1 | <0.01* | 26.9 ± 1.4 | 0.94 | 26.8 ± 1.4 | 0.76 |
| Percent Games Started (%) | 80.9 ± 1.7 | 65.8 ± 2.6 | <0.01* | 73.2 ± 2.6 | <0.01* | 77.2 ± 0.02 | 0.04* |
| Minutes per Game | 71.4 ± 1.5 | 60.3 ± 2.0 | <0.01* | 66.5 ± 1.9 | <0.01* | 69.6 ± 1.8 | 0.28 |
| Goals per 90 min | 0.3 ± 0.02 | 0.2 ± 0.03 | <0.01* | 0.2 ± 0.02 | <0.01* | 0.2 ± 0.02 | 0.03* |
| Shots per 90 min | 1.4 ± 0.09 | 1.4 ± 0.1 | 0.21 | 1.4 ± 0.1 | 0.22 | 1.2 ± 0.1 | 0.49 |
| Shots on Goal per 90 min | 0.7 ± 0.07 | 0.6 ± 0.05 | 0.23 | 0.6 ± 0.07 | 0.87 | 0.5 ± 0.06 | 0.15 |
| Assists per 90 min | 0.1 ± 0.01 | 0.1 ± 0.01 | 0.17 | 0.09 ± 0.01 | 0.47 | 0.08 ± 0.01 | 0.75 |
| Goals Conceded per 90 min | 1.4 ± 0.08 | 1.7 ± 0.2 | 0.09 | 1.5 ± 0.1 | 0.29 | 1.5 ± 0.2 | 0.16 |
| Percent Games with Shutout (%) | 33.8 ± 2.0 | 31.5 ± 2.1 | 0.16 | 33.2 ± 2.4 | 0.89 | 29.1 ± 2.5 | 0.07 |
| Saves per 90 min | 3.7 ± 0.5 | 4.1 ± 1.7 | 0.79 | 2.5 ± 0.4 | 0.06 | 2 ± N/A | N/A |
| Fouls Committed per 90 min | 1.1 ± 0.1 | 1.3 ± 0.08 | <0.01* | 1.3 ± 0.08 | <0.01* | 1.2 ± 0.08 | 0.06 |
| Yellow Cards per 90 min | 0.3 ± 0.08 | 0.2 ± 0.02 | 0.86 | 0.2 ± 0.2 | 0.35 | 0.2 ± 0.02 | 0.35 |
| Red Cards p per 90 min | 0.01 ± 0.003 | 0.01 ± 0.003 | 0.62 | 0.01 ± 0.003 | 0.53 | 0.02 ± 0.01 | 0.39 |

Abbreviations: ACLR — anterior cruciate ligament reconstruction.
[a] Values are given in the form of mean ± standard error.
[b] p-Value <0.05 were considered statistically significant.
* Represents statistically significant difference (p-value <0.05).

reported by Erikson et al. [16], who reported that no significant difference in performance statistics existed after ACLR in Major League Soccer athletes. The major difference between these studies is the sample size.

Although there is indication that professional footballers gradually return to baseline participation in terms of games/season and minutes/game two and three seasons post-ACLR, our data suggests that recovery from this surgery significantly affects short-term performance. Comparative metrics in other sports suggest that this finding may be unique to football [12]. Our data proposes that professional footballers have a higher RTP rate following ACLR than professional athletes in different sports; however, they experience more of a decline in player performance. Mai et al. analyzed pre- and post-ACLR player performance statistics in professional athletes from four different sports leagues: National Football League (NFL); National Basketball Association (NBA); National Hockey League (NHL); and Major League Baseball (MLB) [12]. They reported a RTP rate of 95.8% in NHL players,

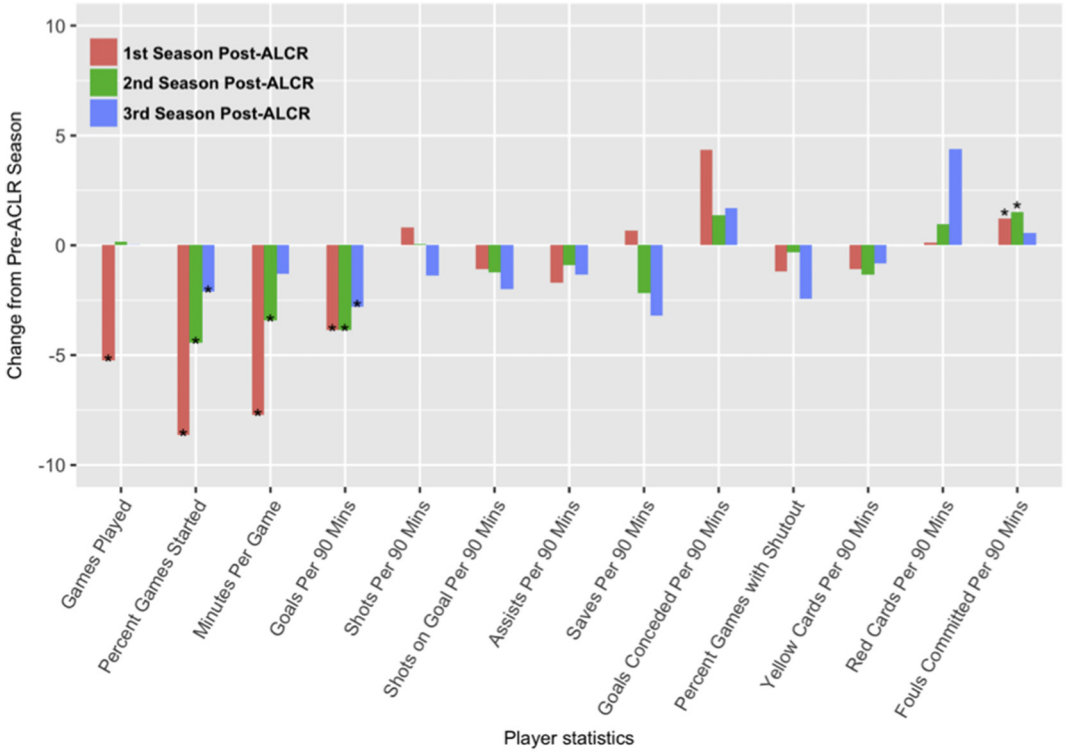


**Figure 1.** Player performance statistics by season. * Represents statistically significant difference from index season (p-value <0.05). Abbreviations: ACLR — anterior cruciate ligament reconstruction.

which was the only sport with a higher RTP rate than our football cohort at 93.2%. Furthermore, NFL players were the only athletes to continue to have a decline in player performance at two and three seasons post-ACLR, similar to our footballers.

The reported differences in the effect of ACLR on RTP and player performance across different sports may be explained by the demands on the knee intrinsic to each sport. The ACL is critical to cutting and pivoting motions, making it reasonable to assume that sports more dependent on inline activity place athletes at a lower risk of ACL tear and subsequent decline in player performance following ACLR. Football requires athletes to cut and pivot frequently, while challenging opponents for possession. Further research is required to aid in answering why a decline in player performance remains evident three seasons post-ACLR in professional footballers.

The limitations of the study are unique to the methodology utilized, which has been reviewed in prior studies [12,18,22]. Because data is derived from public sources, there exists the potential for selection bias for the more accomplished players. We acknowledge there were a number of footballers with ACL tears that were not captured in our search, with the significance of selection bias on our results difficult to determine [23]. Furthermore, without available medical records or imaging, concomitant injuries, surgical technique, choice of graft, and rehabilitative protocols could not be categorized. Reliable data collection was restricted to 2001–2015, which may have excluded players injured prior to this time. Finally, only injury reports, newspaper articles, journals, and blog archives written in English were included, which likely led to a selection bias for players in the English leagues.

## 5. Conclusions

To our knowledge, this study represents the largest cohort of professional footballers analyzing return-to-play and player performance statistics post-ACLR. We conclude that ACL rupture requiring ligament reconstruction leads to a negative impact on the career of a professional footballer. Our data serves to guide expectations for athletes, and allow team physicians to intervene with peri-operative and post-operative protocols to improve these outcomes.

## Conflicts of interest

The authors declare no conflict of interest associated with this manuscript.

## Ethical statement

This manuscript is original and has not been previously published in whole or in part. Furthermore, it has not been simultaneously submitted for publication elsewhere. All authors have contributed meaningfully to the final manuscript.

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