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RESEARCH ARTICLE

THE ACL ECONOMY: WHY A FREE WARM-UP LOSES TO A $26,000 SURGERY IN YOUTH SPORT

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Abstract

Female athletes tear the anterior cruciate ligament (ACL) at about 2.2 times the male rate per hour of play. Free twenty-minute neuromuscular warm-ups can prevent many of these injuries, yet surgery, costing tens of thousands of dollars, remains the usual response. This study asks why. Methods: A narrative synthesis of 28 published sources was combined with a club-level model of 100 female players over one season, using published efficacy, coach-survey and cost data. Results: Warm-ups cut ACL injuries by about 50%, and non-contact injuries in female athletes by about 67%. However, only 12.7% of surveyed coaches delivered them as prescribed. Full delivery would prevent 0.43 to 1.92 tears per 100 players per season and avoid US11,340toUS50,778 in surgical payments for about US$125; observed delivery prevents only 0.05 to 0.24. Clubs bear the costs, while insurers collect most of the savings. Conclusion: Surgery has a seller, a visible moment of need and proof that it worked; prevention has none of these. Three testable propositions and recommendations for leagues, insurers, clubs and sports-technology firms are offered.

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Introduction:-

Every season, a teenage athlete lands from a jump, plants a foot to change direction or decelerates awkwardly, and the knee gives way. In most cases no one has touched her. The anterior cruciate ligament, the band of tissue that stops the shin bone sliding forward beneath the thigh bone, has torn. What follows is familiar to anyone close to youth sport: an MRI scan, a surgeon's consultation, a reconstruction using a graft taken from the athlete's own tendon, and six to twelve months of rehabilitation. The athlete misses a season, sometimes two. Many do not return to the level they played before (Ardern et al., 2014).This is a sports-medicine problem, but it is also a market, and the market has a strange shape. On one side sits a set of structured warm-up programmes, built from running, strength, jumping and balance exercises, that have been tested in randomised trials since the late 1990s (Hewett et al., 1999; Mandelbaum et al., 2005; Soligard et al., 2008; Waldén et al., 2012). They cost almost nothing, need no equipment and take about twenty minutes. On the other side sits reconstructive surgery, billed in one academic centre at an average of US$61,004 per operation (Pan et al., 2023). By most measures the first option is the better buy. It prevents injury rather than repairing it, it works across a whole team at once, and economic models find it saves money compared with doing nothing (Swart et al., 2014; Marshall et al., 2016).Yet the warm-up mostly goes unused, or is used in a diluted form that keeps the name and loses the effect. In a recent survey of youth coaches in New York State, 73% knew that exercises existed to reduce ACL risk and 52.4% said they used them routinely, but

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only 12.7% delivered them with the frequency, timing and content that the evidence supports (MacFarlane et al., 2024). The cheap fix is not being refused. It is being half-adopted, which in some ways is harder to explain.The obvious explanations do not fit well. If the problem were evidence, coaches would not report awareness at 73%. If the problem were price, a programme that costs about US$1.25 per player per season (Swart et al., 2014) would not lose to anything. If the problem were time, the coaches in the survey would have named it, and none of them did (MacFarlane et al., 2024). Something else is going on, and this paper argues that it is better described in the language of business than of medicine. Surgery is a product with a seller, a buyer and an invoice. Prevention is a product with none of the three.

The female-athlete angle sharpens the question. Per hour of exposure, women and girls tear their ACLs at about 2.2 times the rate of men and boys in football (Montalvo et al., 2019), and girls' participation in American high-school sport reached a record 3,536,984 in 2024-25 (National Federation of State High School Associations [NFHS], 2025). Several of the best-known players in the world, including Beth Mead, Vivianne Miedema and Catarina Macario, missed the 2023 Women's World Cup with ACL injuries (Al Jazeera, 2023). The injury has become visible at the top of the sport. Its prevention has not become visible at the bottom.

This paper asks a narrow question: why does an effective, nearly free prevention programme lose to an expensive repair in youth sport, and what would change the outcome? It is written from a management perspective rather than a clinical one. It does not re-test whether neuromuscular training works; the trials have done that. It examines the market around the knee: who pays, who is paid, who sees the result, and who carries the cost when nothing is done.
A note on the paper's own reasoning is worth making early. A first reading of this topic invites a story in which coaches are uninformed and surgeons are self-interested. The evidence supports neither caricature. Coaches mostly know about prevention, surgeons are among the leading authors of the prevention trials (Mandelbaum et al., 2005; Swart et al., 2014), and surgery remains the right treatment for many athletes after a tear (Mather et al., 2013). The more uncomfortable conclusion, reached below, is that every party is acting sensibly given what it is paid for and what it can see, and that the problem sits in the structure that connects them.The remainder of the Introduction reviews the relevant literature and states the objectives. The Materials and Methods section describes the synthesis and the club-level model. The Results section presents findings on burden, efficacy, implementation, cost and modelled impact. The Discussion sets out a proposed explanation, tests it against rival explanations, considers where it could be wrong, and gives limitations and recommendations.

Who tears an ACL, and how often:-
ACL injury in young people is common and growing. Using a large Minnesota health-plan population, Beck et al. (2017) found that ACL tears in patients aged 6 to 18 rose by about 2.3% per year over twenty years. In that population, incidence peaked at 392 per 100,000 person-years in girls at age 16 and 422 per 100,000 in boys at age 17. These population figures can mislead a first-time reader into thinking boys are at greater risk. They are not, per unit of exposure. Boys simply play more organised contact and pivoting sport. When the denominator is time spent playing, the picture reverses. In a meta-analysis of 28 football studies, Montalvo et al. (2019) found an incidence rate of 2.0 ACL injuries per 10,000 athlete exposures for women and 0.9 for men, a rate ratio of 2.2, with the disparity present at every level of play.This distinction between population counts and exposure rates matters for the business argument later. A health system or insurer sees totals. A coach of a girls' team sees risk per player. The two observers are looking at the same injury through different denominators, and each draws a different conclusion about how urgent it is.

Does prevention work?:-
The efficacy literature is unusually consistent for a sports-medicine intervention. Early prospective work by Hewett et al. (1999) showed that a six-week neuromuscular programme reduced serious knee injuries in female high-school athletes. Mandelbaum et al. (2005) reported a large reduction in ACL injuries among female youth football players using the Prevent injury and Enhance Performance (PEP) programme over two seasons. Soligard et al. (2008) tested the FIFA 11+ warm-up in a cluster-randomised trial of young female footballers and found a lower risk of injuries overall and of severe injuries. In the largest ACL-specific trial in adolescent girls, Waldén et al. (2012) randomised 230 Swedish clubs and 4,564 players aged 12 to 17. Seven ACL injuries occurred in the intervention group against 14 in the control group, a rate ratio of 0.36, or a 64% reduction.

Pooled analyses agree. Gagnier et al. (2013) found a pooled ACL injury rate ratio of 0.49 across 14 studies and about 27,000 athletes, and Donnell-Fink et al. (2015) found a similar ratio of 0.49 across 12 studies and more than

17,000 athletes. Thorborg et al. (2017) reported a 39% reduction in all football injuries for FIFA 11+. Webster and Hewett (2018) pooled eight earlier meta-analyses and estimated about a 50% reduction in all ACL injuries and about a 67% reduction in non-contact ACL injuries in female athletes. A cluster-randomised trial in Canadian youth football found a 38% lower injury rate with neuromuscular training than with a standard warm-up (Marshall et al., 2016).There is an honest caveat. Many trials report wide confidence intervals for ACL injuries alone, because ACL tears are rare events even in high-risk groups. In Waldén et al. (2012), for example, the absolute difference in ACL rate per 1,000 playing hours was not statistically significant even though the rate ratio was. The case for prevention rests on the consistency of many studies, not on any single one.

Dose, compliance and decay:-

A second body of work shows that the effect depends on how faithfully the programme is delivered. Sugimoto et al. (2012) pooled six studies of female athletes and found that high compliance was associated with far lower ACL injury rates than low compliance, describing a likely inverse dose-response relationship. In a secondary analysis of the Swedish trial, Hägglund et al. (2013) found that players in the highest compliance group had an 88% lower ACL injury rate than those in the lowest. The same analysis showed something just as important for this paper: compliance fell through the season, by about 3% per month at team level and 5% per month at player level. A programme that starts well tends to fade.The implication is that efficacy in a trial is a ceiling, not a forecast. Trials often include research staff, coach training and regular contact with the clubs. Ordinary clubs have none of these. What an evidence summary calls a 64% reduction is closer to the best case for a well-supported team.

From trial to practice: implementation in sport:-

Implementation science explains why effective interventions often fail to spread. The RE-AIM framework asks not only whether an intervention works but whether it reaches the target population, is adopted by settings, is implemented as intended and is maintained over time (Glasgow et al., 1999). Finch (2006) adapted this logic for sport in the Translating Research into Injury Prevention Practice (TRIPP) framework, arguing that injury research usually stops at efficacy and rarely studies whether athletes, coaches and organisations will actually use what works.
Empirical work on youth sport confirms the gap. MacFarlane et al. (2024) surveyed 126 coaches and found that awareness (73%) far exceeded routine use (52.4%), which in turn far exceeded evidence-based implementation (12.7%). Coaches who did not use a programme most often cited a lack of training (63.2%), and none cited time or effort as a significant barrier. Higher competitive level and coaching several teams were associated with adoption, while the sex of the athletes coached was not. That last finding is striking: coaches of girls, who face the higher per-exposure risk, were no more likely to adopt.

The economics of prevention:-

Economic studies of ACL prevention point one way. Swart et al. (2014) modelled 10,000 athletes aged 14 to 22 and found that universal neuromuscular training, costing about US$1.25 per player per season, reduced ACL injury incidence from 0.030 to 0.011 per player per season and saved about US$275 per player per season compared with no intervention. It was also preferable to screening athletes and training only those judged high-risk. Marshall et al. (2016) found that a neuromuscular warm-up reduced youth football injuries by 38% and healthcare costs by 43%, and projected that province-wide use in Alberta would avoid about 4,965 injuries and more than C$2.7 million in healthcare costs in one season.On the other side of the ledger, Mather et al. (2013) estimated the lifetime societal cost of an ACL tear treated with reconstruction at US$38,121, against US$88,538 for treatment with rehabilitation alone, and concluded that surgery was the less costly option for society once a tear has occurred. That result is easy to misread as a case for surgery over prevention. It is not. It compares two responses to an injury that has already happened. Prevention is a different decision made earlier, by different people.Two broader ideas from public-health economics help explain why favourable numbers do not produce action. Rose (1985) described the prevention paradox: a measure that brings large benefits to a population may offer little to each participating individual, so individuals feel little reason to adopt it. McCullough (2019) described the wrong-pocket problem, in which the party that pays for a preventive investment is not the party that collects the savings, so a programme with a positive return can still be underfunded. Rogers (2002) observed that preventive innovations diffuse unusually slowly because their benefit is a non-event that may arrive far in the future and cannot be observed directly.

What this paper adds:-

Each of these literatures explains part of the gap, but each holds something fixed. The efficacy literature holds implementation fixed and asks whether the programme works. The implementation literature examines coaches and clubs but rarely follows the money. The economic literature calculates who saves but treats adoption as a parameter.

The public-health concepts of the prevention paradox and wrong pockets are general and have not been applied in detail to the youth-sport knee.This paper's contribution is to place these strands in one frame and to name the specific commercial properties that surgery has and prevention lacks. It is offered as a proposed explanation built from published evidence, not as a confirmed theory. It becomes stronger only if the propositions in Section 4 hold up when tested on primary data.

Objectives:-

This study has four objectives:-

1. To summarise the evidence on how much structured neuromuscular warm-ups reduce ACL injuries in young female athletes, and how that effect depends on compliance.
2. To measure the gap between that evidence and the way programmes are actually delivered by youth coaches.
3. To compare the cost structure of prevention with that of surgical repair, and to model what the observed implementation gap means in injuries and dollars for a typical club.
4. To propose and test against rival explanations an account of why the cheaper option loses, and to derive practical recommendations.

Materials and Methods:-

Design:-

This is a narrative synthesis of published evidence combined with a simple deterministic model. It is not a systematic review. Sources were identified through searches of PubMed, journal websites, PEDro and professional and news sources up to October 2026, using combinations of the terms anterior cruciate ligament, injury prevention, neuromuscular training, FIFA 11+, compliance, implementation, cost and cost-effectiveness. Priority was given to randomised trials, meta-analyses and economic evaluations. Twenty-eight sources are cited.

The club-level model:-

To translate published effect sizes into terms a club or insurer would recognise, the paper models a hypothetical group of 100 female players aged roughly 12 to 18 playing one season of football or a similar pivoting sport. The inputs are listed in Table 3. Two baseline risks are used to bracket the range found in the literature: 0.67% per player per season, the ACL rate in the control arm of the Swedish adolescent trial (Waldén et al., 2012), and 3.0% per player per season, the no-intervention rate assumed by Swart et al. (2014) for athletes in higher-risk sports.Efficacy under full delivery is taken as a 64% reduction (Waldén et al., 2012). This sits between the 63% reduction assumed by Swart et al. (2014) and the 67% reduction in non-contact injuries estimated by Webster and Hewett (2018). Three delivery scenarios are compared. In the first, every team delivers the programme as prescribed. In the second, every team that reports routine use (52.4%) receives the full effect, which is an optimistic upper bound for current practice. In the third, only teams that meet evidence-based criteria (12.7%) receive any effect, which is a conservative lower bound (MacFarlane et al., 2024). The truth for ordinary clubs most likely lies between the second and third scenarios.

For each scenario the model calculates ACL tears prevented, the number of player-seasons of full delivery needed to prevent one tear, and the surgical payments avoided. Avoided payments use the mean amount actually paid per reconstruction, US$26,447 (Pan et al., 2023), rather than the much higher billed charge. Lifetime societal costs from Mather et al. (2013) are shown as an alternative. Programme cost uses the US$1.25 per player per season estimate of Swart et al. (2014). Coach time is estimated as six teams, two sessions per week, 30 weeks and 20 minutes per session, giving 120 coach-hours per 100 players.The model is deliberately simple. It does not discount future costs, does not include second injuries or later osteoarthritis, and does not value the athlete's lost season. Each of these omissions makes prevention look less valuable than it probably is, so the model is conservative in favour of the status quo.

Analytical approach:-

Findings were organised along the chain that connects evidence to impact: burden, efficacy, adoption, fidelity and cost. For the explanatory argument in Section 4, the paper compares the two products, prevention and surgery, on the commercial features that typically drive adoption of a product: who sells it, when the need for it is felt, who pays, who receives the benefit and how the benefit is shown. Rival explanations are then examined to see whether they account for the evidence better.

Ethics:-
The study used only published, aggregate data and involved no human or animal participants. Ethical approval was not required.

Results:-

The burden falls disproportionately on girls:-
The three measures of burden point in the same direction. Per exposure, female footballers tear ACLs at 2.2 times the male rate (Montalvo et al., 2019). Paediatric ACL tears have been rising by about 2.3% per year (Beck et al., 2017). And the consequences outlast the injury. After reconstruction, 81% of athletes return to some sport, but only 65% return to their pre-injury level and 55% to competitive sport (Ardern et al., 2014). Among athletes under 25 who return to sport, about 23% go on to a second ACL injury (Wiggins et al., 2016). In a Swedish cohort of 103 female footballers examined twelve years after an ACL injury, more than half had knee osteoarthritis, even though the women were only 26 to 40 years old (Lohmander et al., 2004). Table 2 combines these consequences with the financial cost.

Prevention works, and its effect depends on dose:-
Table 1 summarises the main efficacy evidence, and Figure 1 shows the size of each reported effect.

Table 1. Main evidence on structured warm-up programmes and ACL or overall injury risk

Study	Design and population	Outcome	Reported effect
Hewett et al. (1999)	Prospective study, female high-school athletes	Serious knee injuries	Fewer injuries in trained athletes
Mandelbaum et al. (2005)	Prospective study, female youth football, PEP programme, two seasons	ACL injuries	Large reduction in both seasons
Soligard et al. (2008)	Cluster RCT, young female footballers, FIFA 11+	All and severe injuries	Lower risk of injury overall and of severe injury
Waldén et al. (2012)	Cluster RCT, 4,564 girls aged 12–17, 230 clubs	ACL injuries	Rate ratio 0.36 (64% reduction)
Gagnier et al. (2013)	Meta-analysis, 14 studies, about 27,000 athletes	ACL injuries	Rate ratio 0.49
Donnell-Fink et al. (2015)	Meta-analysis, 12 studies, more than 17,000 athletes	ACL injuries	Rate ratio 0.49 (51% reduction)
Marshall et al. (2016)	Cluster RCT, youth football aged 13–18	All injuries; healthcare costs	38% fewer injuries; 43% lower costs
Thorborg et al. (2017)	Meta-analysis, 4 RCTs of FIFA 11+	All injuries	Rate ratio 0.61 (39% reduction)
Webster & Hewett (2018)	Meta-analysis of 8 meta-analyses	Non-contact ACL, female athletes	Odds ratio 0.33 (about 67% reduction)
Hägglund et al. (2013)	Secondary analysis of the Swedish RCT	ACL injuries by compliance	88% lower in highest vs lowest compliance

Note: RCT: randomised controlled trial. Effects are compared with control groups or, for Hägglund et al., with the lowest-compliance group.

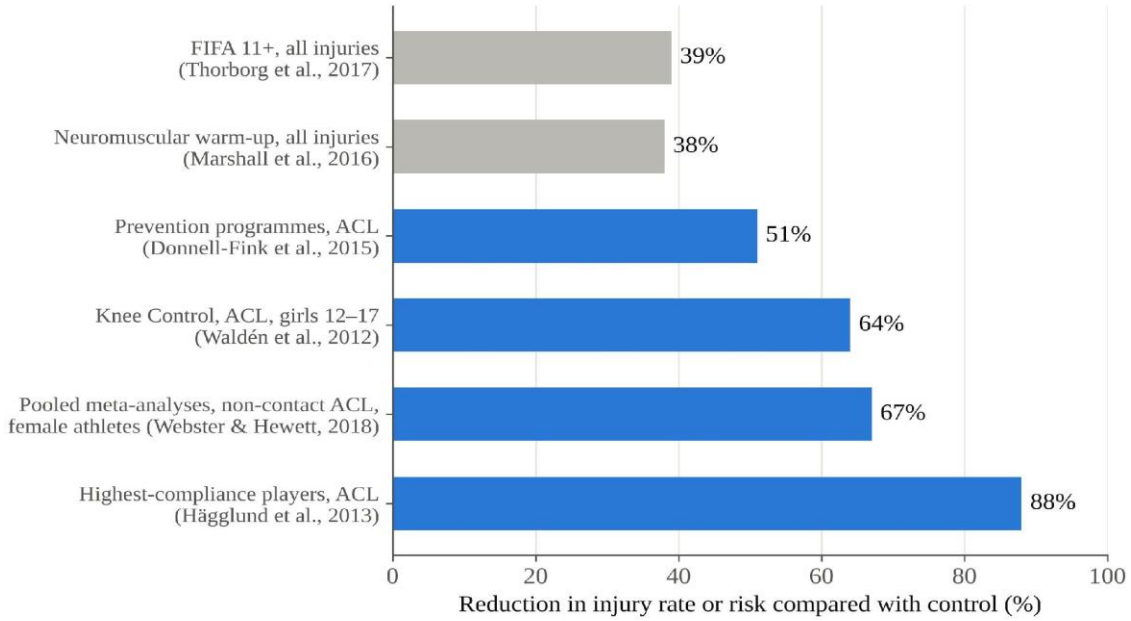


Figure 1. Reported reductions in injury from structured warm-up programmes. Blue bars show ACL injuries; grey bars show all injuries. Sources as labelled.

Three points stand out. First, ACL-specific reductions cluster between about 50% and 67%, which is large for any preventive measure in medicine. Second, the effect is larger for non-contact injuries in female athletes, the group at highest risk. Third, the highest-compliance comparison (88%) is much larger than the average trial effect, which means that the average trial result already includes a good deal of under-delivery.

The implementation cascade:-

Figure 2 presents the coach survey of MacFarlane et al. (2024) as a cascade. Each step is a subset of the one before.

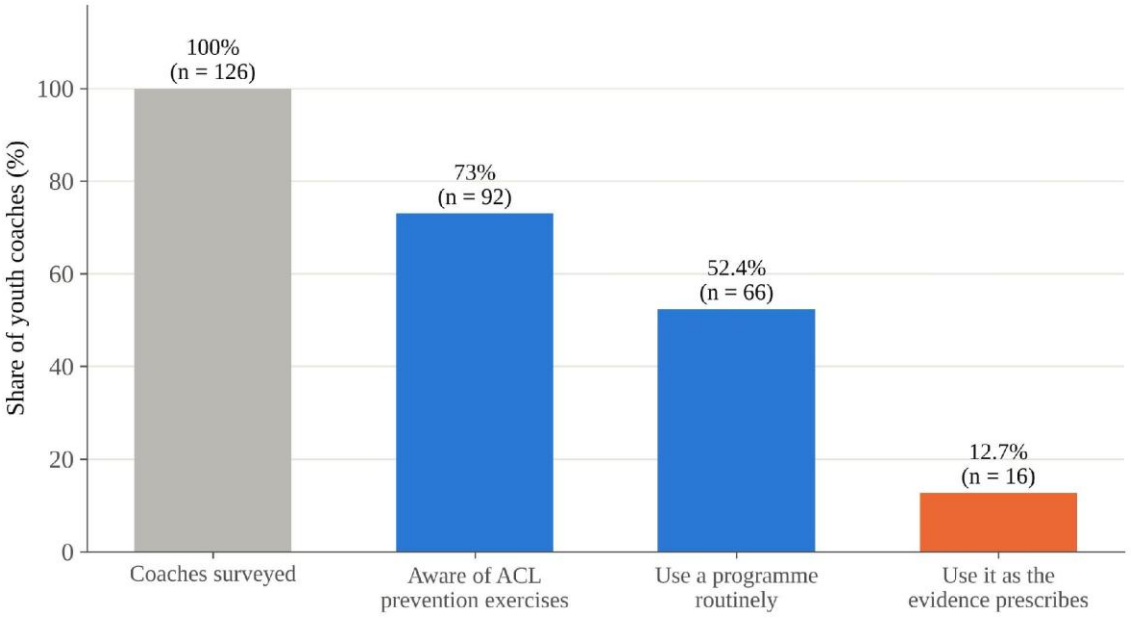


Figure 2. From awareness to evidence-based use among 126 youth coaches. Data from MacFarlane et al. (2024).

The drop from awareness to evidence-based use is roughly six-fold. More than a quarter of coaches who knew the exercises existed did not use them at all, and of the 66 who said they used them routinely, only 16 met the study's implementation criteria. Among routine users, 55% used the exercises in preseason, and fewer than half of those started more than six weeks before the season (MacFarlane et al., 2024). Combined with the monthly decline in compliance reported by Hägglund et al. (2013), this suggests that even teams that start the season well tend to drift.

The cascade also changes how the efficacy numbers should be read. If only the 12.7% of teams that deliver the programme properly receive its effect, a 64% reduction at team level becomes about an 8.1% reduction across all teams. If every routine user received the full effect, the population reduction would be about 33.5%. A programme that works very well where it is used becomes a modest one across the sport, because of who uses it and how.

Table 2. What one ACL tear costs and leaves behind

Measure	Value	Source
Hospital resource cost of reconstruction (time-driven activity-based costing)	US$2,865 (patellar-tendon graft) to US$3,377 (hamstring graft)	Huyke-Hernández et al. (2022)
Mean amount paid for reconstruction (insurer plus patient)	US$26,447	Pan et al. (2023)
Mean amount billed for reconstruction	US$61,004	Pan et al. (2023)
Lifetime societal cost, treated with reconstruction	US$38,121	Mather et al. (2013)
Lifetime societal cost, treated with rehabilitation only	US$88,538	Mather et al. (2013)
Return to competitive sport after reconstruction	55%	Ardern et al. (2014)
Second ACL injury, athletes under 25 who return to sport	About 23%	Wiggins et al. (2016)
Radiographic knee osteoarthritis 12 years after injury, female footballers	More than half	Lohmander et al. (2004)

Note: Cost figures come from different institutions and years and are shown for scale, not as a single consistent estimate. Pan et al. (2023) report 28 patients at one academic centre.

Two price tags:-

Figure 3 places the cost of prevention beside the cost of repair on a logarithmic scale, because on an ordinary scale the prevention bar would be invisible.

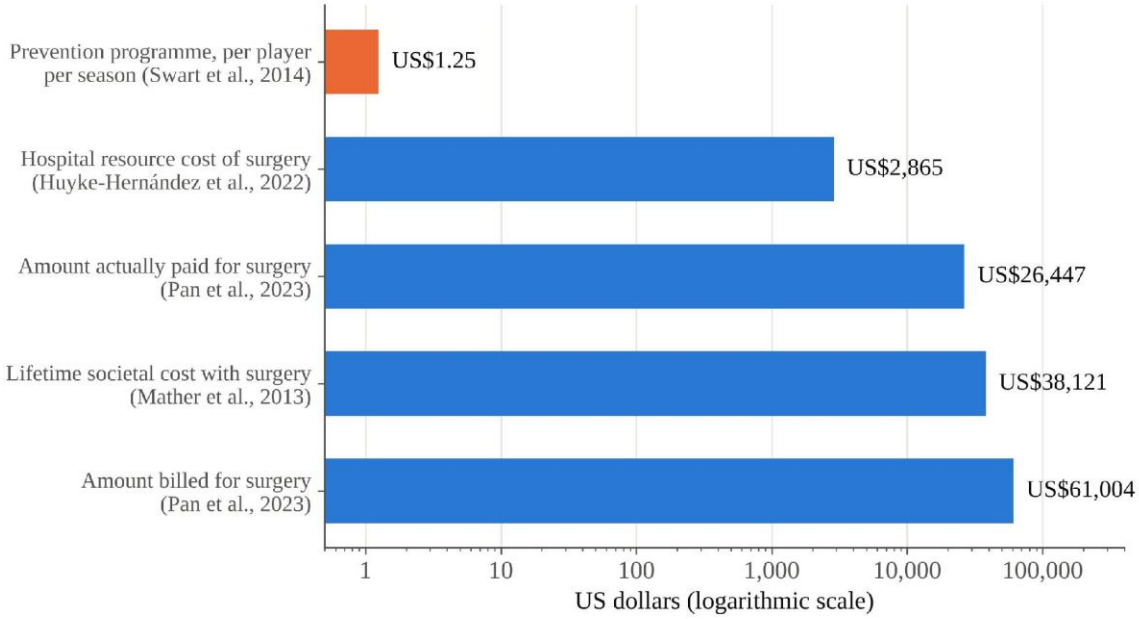


Figure 3. The cost of prevention and the costs of surgical repair, US dollars, logarithmic scale. Sources as labelled; figures come from different settings and years.

The figure carries a second finding that is easy to miss. The gaps between the four surgical bars are themselves large. A time-driven costing study put the hospital's own resource cost of a reconstruction at about US$2,865 to US$3,377 (Huyke-Hernández et al., 2022). In a different centre, the mean billed charge was US$61,004 and the mean amount actually paid was US$26,447 (Pan et al., 2023). The studies come from different institutions and are not a matched comparison, so no precise margin can be calculated from them. But they show that surgery sits inside a pricing system with room between what an operation consumes, what is charged and what is paid. Prevention has no such system. There is no billing code for a warm-up delivered by a volunteer coach on a Tuesday evening.

What the gap costs a club:-

Table 3 lists the model inputs, and Table 4 gives the results.

Table 3. Inputs to the club-level model (100 female players, one season)

Input	Value used	Source or basis
Baseline ACL risk, lower-risk setting	0.67% per player per season	Control arm, Waldén et al. (2012)
Baseline ACL risk, higher-risk setting	3.0% per player per season	No-intervention rate, Swart et al. (2014)
Efficacy under full delivery	64% reduction	Waldén et al. (2012)
Share of teams with routine use	52.4%	MacFarlane et al. (2024)
Share of teams with evidence-based use	12.7%	MacFarlane et al. (2024)
Payment avoided per ACL tear prevented	US$26,447	Mean amount paid, Pan et al. (2023)
Lifetime societal cost per tear (alternative)	US$38,121	Mather et al. (2013)
Programme cost	US$1.25 per player per season	Swart et al. (2014)
Coach time	120 hours (6 teams × 2 sessions × 30 weeks × 20 minutes)	Assumption

Table 4. Modelled results per 100 female players per season

Scenario	Expected tears without programme	Tears prevented	Surgical payments avoided (US$)	Lifetime societal cost avoided (US$)
Lower risk, full delivery	0.67	0.43	11,340	16,346
Lower risk, all routine users effective	0.67	0.22	5,940	8,562
Lower risk, evidence-based users only	0.67	0.05	1,440	2,076
Higher risk, full delivery	3.00	1.92	50,778	73,192
Higher risk, all routine users effective	3.00	1.01	26,598	38,339
Higher risk, evidence-based users only	3.00	0.24	6,448	9,294

Note: Calculated from the model inputs from the inputs in Table 3. Values are rounded; dollar figures were calculated before rounding the number of tears prevented.

Several results follow. Under full delivery, the programme prevents between 0.43 and 1.92 ACL tears per 100 players per season. The number of player-seasons of full delivery needed to prevent one tear is about 233 in the lower-risk setting and 52 in the higher-risk setting. With teams of about 17 players, that means a coach who delivers the programme properly prevents one ACL tear roughly every 14 seasons in a lower-risk setting and every 3 seasons in a higher-risk one.Measured in money, full delivery avoids between US$11,340 and US$50,778 in surgical payments per 100 players per season, against a programme cost of about US$125. That is a ratio of roughly 90 to 1 in the lower-risk setting and about 400 to 1 in the higher-risk setting. Even in the most pessimistic scenario, where only evidence-based users benefit and risk is low, avoided payments of US$1,440 are more than eleven times the programme's cost. On any of these numbers the programme is worth paying for.Figure 4 shows how the benefit grows as more teams deliver the programme as prescribed. The relationship is linear by construction, so its value is not in its shape but in where current practice sits on it.

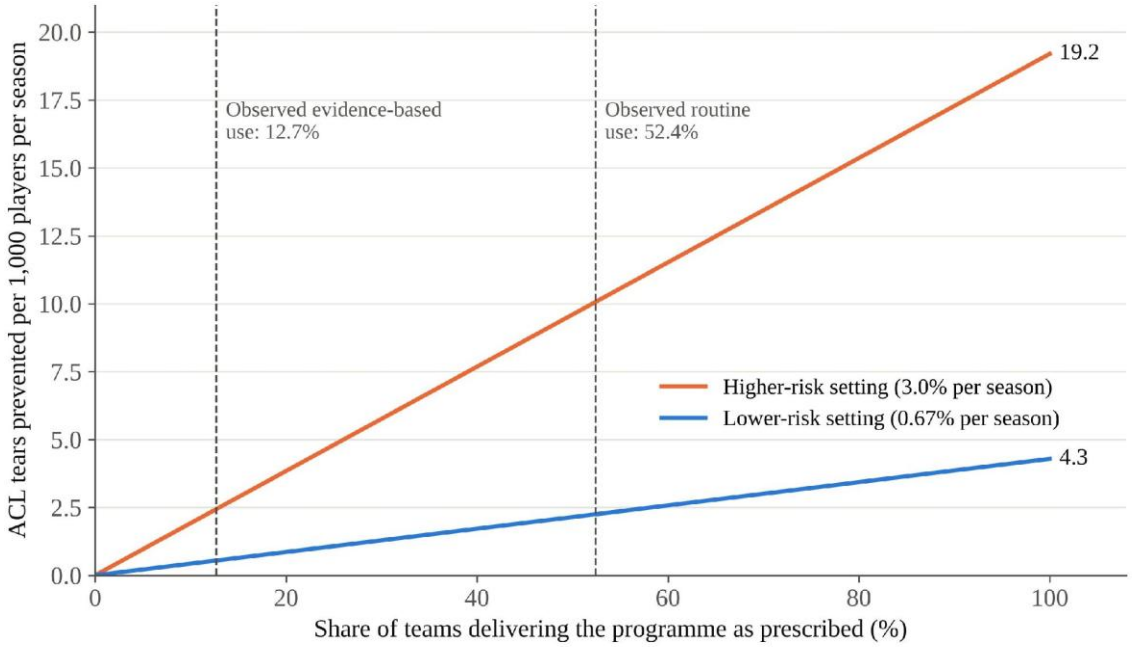


Figure 4. ACL tears prevented per 1,000 female players per season as the share of teams delivering the programme as prescribed rises. Dashed lines mark observed evidence-based use (12.7%) and routine use (52.4%) from MacFarlane et al. (2024). Efficacy under full delivery is set at 64%.

At observed evidence-based use, the programme prevents about 0.5 tears per 1,000 players per season in the lower-risk setting and about 2.4 in the higher-risk setting. Full delivery would prevent about 4.3 and 19.2 respectively. Most of the available benefit is therefore not being collected. The largest gain available to youth sport is not a better programme. It is the delivery of the programme that already exists.

Where the money and the effort land:-

The model's most important output is not a single number but a mismatch. The 120 coach-hours are spent at the club, usually by volunteers or modestly paid coaches, out of practice time that could go to skills or tactics. The surgical payments avoided would otherwise have been paid mostly by insurers: in Pan et al. (2023), insurance paid US$26,045 of the mean US$26,447, and patients paid US$402. The long-term benefits of avoiding a second injury or early osteoarthritis accrue to the athlete years later, often after she has left the club. None of these gains returns to the coach who spent the time. This is the wrong-pocket problem described by McCullough (2019), arriving at the level of a single sports team.

Discussion:-

A proposed explanation: what surgery has that prevention lacks:-

The findings suggest that the gap is not mainly about evidence or price. The paper proposes instead that adoption follows three commercial properties. Surgery has all three. Prevention has none.

- **A seller.** Surgery is delivered by a professional who is trained, paid and organised to deliver it, inside an institution that bills for it and a device industry that supplies it. Every reconstruction is someone's job. Prevention has no comparable seller. The programme is free, so no one earns a margin by promoting it, training coaches in it or checking that it is done properly. FIFA, research groups and clinics have published excellent materials, but publication is not distribution. The coach survey found that lack of training, not lack of awareness or time, was the barrier most often named (MacFarlane et al., 2024). Training is precisely what a seller would provide.
- **A moment of need.** Surgery is demanded at a moment no one can ignore: an injured athlete, a swollen knee, an MRI result. Prevention asks for effort when nothing is wrong, twice a week, for an entire season. Rogers (2002) noted that preventive innovations spread slowly because the reward is delayed and uncertain. The model makes that delay concrete: a coach may deliver the programme faithfully for three to fourteen seasons before it prevents a single tear that would otherwise have happened on her team.

• **A receipt.** Surgery produces visible proof. There is a scar, a recovery, a return to play and a bill. Prevention produces a non-event. The ACL that did not tear does not appear in any record, and no athlete knows that she was the one protected. A coach whose team has no ACL injuries cannot tell whether that was the programme or luck. A coach whose player tears an ACL despite the programme may conclude, wrongly, that it does not work. Feedback, which drives the adoption of most products, is missing or misleading.

To these three properties the findings add a fourth condition that concerns money rather than the product itself. The costs of prevention fall on the club, while the savings fall on insurers and on the athlete's future self (Section 3.6). Even a coach who understood the numbers perfectly would be asked to spend her own team's practice time to produce savings that appear on someone else's balance sheet.

Three propositions:-

If the explanation is correct, it implies outcomes that can be tested:-

Proposition 1. Adoption and fidelity will be higher where someone is paid or accountable for delivering prevention, for example where a club employs an athletic trainer or physiotherapist, or where a league requires and audits the warm-up, than where delivery depends on volunteer coaches.

Proposition 2. Programmes that produce visible feedback, such as tracking completion, showing movement-quality improvements or reporting team injury rates against a benchmark, will decay more slowly through the season than programmes that rely on coaches' memory and goodwill.

Proposition 3. Where the party that saves money also pays for prevention, for example an insurer or integrated health system that funds coach training for the clubs it covers, uptake will be higher than where costs and savings are separated.

Rival explanations:-

Several other explanations deserve a hearing:-

- **Coaches do not know.** This is partly true but cannot carry the weight. In the survey, 73% of coaches were aware of the exercises, while only 12.7% used them properly (MacFarlane et al., 2024). Information campaigns alone would address the smallest part of the cascade.
- **It takes too much time.** Twenty minutes is real time in a ninety-minute practice. But the coaches who did not adopt did not name time or effort as a barrier (MacFarlane et al., 2024). Time may matter more for fidelity, explaining why programmes are shortened, than for adoption itself. This is consistent with, rather than opposed to, the proposed explanation, since a seller would usually help redesign the product around such objections.
- **Surgeons and device firms prefer surgery.** This explanation is tempting and mostly unsupported. Orthopaedic surgeons led several of the key prevention studies (Mandelbaum et al., 2005; Swart et al., 2014), and nothing in the reviewed evidence suggests active opposition to prevention. The more accurate statement is structural: no one in the system is paid to prevent ACL tears, while many people are paid to repair them. That is an absence of incentives, not the presence of a conspiracy.
- **The evidence is not strong enough.** ACL injuries are rare, and single trials have wide confidence intervals. A sceptical coach might reasonably wait. But the consistency across trials and meta-analyses (Table 1), and the economic modelling (Swart et al., 2014; Marshall et al., 2016), make this a weak reason for inaction. It is better understood as one more effect of the missing receipt: a coach cannot see the evidence play out on her own team.

Where this argument could be wrong:-

The explanation has weaknesses that should be stated plainly. The implementation data come from a single region and 126 coaches, and the survey had non-response bias (MacFarlane et al., 2024). Coaches in other countries, sports or competitive levels may behave differently. The three properties are inferred from the comparison of two products rather than measured directly, and it is possible that cultural factors, such as the belief that warm-ups are for elite athletes or that girls' teams should copy boys' training, explain more than incentives do. Finally, the model treats efficacy as fixed, while real-world efficacy may be lower even among teams that meet the survey's implementation criteria. If a primary study found that paid delivery and visible feedback did not raise fidelity, the explanation offered here would be substantially weakened.

Implications for the business of sports medicine:-

Read as a market, youth ACL prevention is a product with proven value, almost no marginal cost and no distribution channel. That combination is unusual, and it creates openings. Sports-technology firms could supply the missing receipt by recording completion, scoring movement quality from phone video and reporting team trends against

benchmarks, though such products would need their own evidence before claiming to reduce injuries. Insurers and integrated health systems could act as the missing buyer, since they hold the savings. Leagues and governing bodies could act as the missing seller by making a prescribed warm-up a condition of registration and training coaches in it, much as many sports now require concussion education. None of these routes requires a new medical discovery. Each requires someone to own a job that currently belongs to no one.

Limitations:-

The study has six main limitations:-

- **Narrative, not systematic.** Sources were selected through targeted searches, and relevant studies may have been missed.
- **Implementation data from one survey.** The cascade relies on 126 coaches in one region of New York State. The proportions may differ elsewhere.
- **Cost figures from different settings.** The surgical costs come from different institutions, years and methods. They show scale, not a matched comparison, and they reflect the United States, where prices are high.
- **A simple model.** The model omits second injuries, osteoarthritis, lost seasons and discounting, and treats efficacy as fixed. It is designed to illustrate orders of magnitude rather than to predict outcomes for any particular club.
- **Coach time assumed.** The 120 coach-hours figure is the author's assumption based on a typical programme schedule, not a measured value.
- **Explanation not tested.** The three properties are proposed from secondary evidence. They have not been tested on primary data, so the explanation should be treated as a framework for future research.

Recommendations:-

- **For leagues and governing bodies.** Make a recognised neuromuscular warm-up a condition of team registration in girls' pivoting sports, require short coach training to deliver it and check delivery during the season.
- **For insurers and health systems.** Fund coach training and delivery support for the clubs whose members you cover. The modelled return is large, and you are the party that collects it.
- **For clubs and schools.** Assign responsibility for the warm-up to a named person, such as an athletic trainer, physiotherapist or senior coach, rather than leaving it to each coach's discretion, and start it at least six weeks before the season.
- **For sports-technology firms.** Build products that make prevention visible, such as completion tracking and movement-quality feedback, and test them in trials before claiming that they reduce injury.
- **For researchers.** Test the three propositions in Section 4 directly, using primary data on who delivers the programme, what feedback coaches receive and who pays.

Conclusion:-

The ACL problem in youth sport is not that medicine lacks an answer. A twenty-minute warm-up, free to use and tested in trials involving thousands of athletes, reduces ACL injuries by about half, and in female athletes, who carry about twice the per-exposure risk, by as much as two-thirds for non-contact injuries. The problem is that the answer is not delivered. In the coach survey reviewed here, only 12.7% of coaches used a programme as the evidence prescribes, and the model in this paper shows that most of the available benefit is therefore lost.The paper's proposed explanation is that prevention fails as a product rather than as a science. Surgery has a seller, a moment of need and a receipt. Prevention has none of them, and its costs and savings fall on different parties. Seen this way, the cheap fix does not lose to the expensive one because people prefer surgery. It loses because the system is organised to deliver surgery and is not organised to deliver anything else.The lesson reaches beyond the knee. Many of the most effective interventions in health are cheap, preventive and invisible when they succeed. Unless someone is made responsible for delivering them, and unless their results can be seen, they will keep losing to treatments that are expensive, reactive and easy to count.

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