Systematic Review of Cost-Effective Analyses in Sports Medicine from 2014 to 2020

Casey Slattery, MD[1,2]; Mia S. Hagen, MD[1]; Amy Cizik, PhD, MPH[1]; Albert O. Gee, MD[1]; Christopher Kweon, MD[1]

[1]Department of Orthopaedic Surgery and Sports Medicine, University of Washington, Seattle, Washington

Changed Affiliation

[2]Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center, Albuquerque, New Mexico

Corresponding Author Christopher Kweon, MD. Department of Orthopaedic Surgery and Sports Medicine, 3800 Montlake Blvd NE, Seattle, WA 98195 (email: ckweon@uw.edu).

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ABSTRACT

The quality of recent cost-effectiveness studies and whether there is sufficient evidence to achieve value-based health care in sports medicine are unknown. The purpose of this study was to perform a systematic review of recent cost-effective analyses (CEA) in sports medicine to determine the quality of publications from the last 6 years. A literature search was conducted for CEA studies on diagnostic tests, treatment options, and surgical procedures for sports medicine-related conditions between 2014 and 2020 in the United States. Two reviewers scored each study using the Quality of Health Economic Studies (QHES) instrument to assess methodological quality. Eighteen CEA studies met the inclusion criteria. The quality of the studies ranged from moderate to excellent using the QHES instrument (mean: 83.3, range: 52-100). The quantity and mean quality of CEA studies in sports medicine have increased since 2014. More high-quality randomized control trials are needed to reduce bias and to further improve value-based health care in sports medicine.

Keywords: Cost-Effective Analysis, Sports Medicine, Cost

INTRODUCTION

Allocation of funds and cost control have become critical components in healthcare as spending continues to increase.[1] Surgeons are in a unique position to control the cost of surgical care because most of the decision-making is surgeon-led. As such, surgeons must become familiar with the economics impacting healthcare policy.[2] In recent years, cost-containment strategies have focused on delivering value-based healthcare and have led to an increased number of published studies using cost-effective analytic (CEA) techniques.[3] Surgical literature, especially studies concerning orthopaedics, lag behind other fields of medicine in terms of studying, reporting, and prioritizing value-based care.[4]

CEA compares the relative costs and outcomes (ie, effects) of different treatment options, which is an important tool to identify procedures that allow the greatest outcome improvements at the lowest cost. CEA models collect data from various sources, and these models project outcomes and costs over a longer timeframe than randomized control trials (RCT).[5] In 1996, the First Panel of Cost Effectiveness in Health and Medicine summarized and provided guidance for CEA.[6] Subsequently, there has been an increase in the number of CEA studies across all disciplines of medicine.[7] In 2016, the Second Panel of Cost Effectiveness emphasized improvements in CEA model development and data reporting, which has resulted in better methodology in subsequent CEA studies in orthopaedics.[5,8]

Despite the growth of CEA literature in other fields,[9-15] there is still a lack of studies examining CEA within sports medicine. For instance, a 2014 systematic review found only 12 United States-based studies over a 16 year time period, with an average Quality of Health Economic Studies (QHES) rating of 81.8. The purpose of our study was to assess the quality and evaluate the number of recent sports-medicine CEA studies since the 2014 systematic review.[3] CEA studies in sports medicine are important given the elective outpatient nature of the field. We hypothesized an increase in both the quantity and quality of cost-effective analyses of sports-medicine conditions.

METHODS

A literature review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to identify all studies that: 1) involved an orthopaedic sports-medicine procedure or intervention, 2) performed a cost-effective analysis, 3) were clinically-based, 4) pertained to the United States healthcare system, and 5) were published after January 1, 2014.[16] The studies that were published after January 1, 2014 were not included in the systematic review published in 2014.

The online databases PubMed, Embase, Web of Science, and Scopus were used to search for appropriate

Table 1. *Identified Studies and Conclusions*

Study	Year	Area of Analysis	Duration	Conclusions
Rogers et al[28]	2019	Meniscal repair vs partial meniscectomy for red-red zone	40 years	$3,935 ICER/QALY favoring meniscal repair as the dominant procedure.
Bendich et al[32]	2018	Meniscus allograft transplant	30 years	Not currently cost effective.
Lester et al[30]	2018	Meniscal repair vs partial meniscectomy in ACLR	40 years	Increase of 0.84 QALYS with a repair compared to a meniscectomy.
Min et al[27]	2018	Open Latarjet vs arthroscopic Bankart	Lifetime	Bankart is more cost effective, although with a higher failure rate.
Cunningham et al[36]	2017	FAI diagnosis	Lifetime	H&P with injection has ICER of $59,228/QALY compared to H&P alone. WTP threshold favoring injection for GP is $70,000 and $990,000 for hip specialists.
Dornan et al[23]	2017	RCR vs RTSA for massive rotator cuff tear	Lifetime	RTSA after RCR had incremental effectiveness of +0.11 QALYs with ICER of $3,959.55/QALY compared to revision RCR after RCR.
Gyftopoulos et al[25]	2017	MRI vs US for rotator cuff tear	2 years	US least costly ($1,385) and most cost effective, but not dominant over MRI. MRI was most effective (1.332 QALYS).
Kang et al[24]	2017	Massive irreparable rotator cuff tear: RTSA vs AD-BT vs HA vs PT	Lifetime	RTSA had an incremental gain of 1.0 QALYs ($25,522/QALY) over AD-BT.
Stewart et al[35]	2017	ACLR in athletes	6 years	ACLR vs physical therapy is 0.372 or $22,702/QALY gained.
Feeley et al[29]	2016	Meniscal repair vs partial meniscectomy	Lifetime	Meniscal repair had a 0.19 QALY gain over partial meniscectomy and $2,701 cost discount.
Lodhia et al[37]	2016	Hip arthroscopy for labral tear	Lifetime	Surgery had 3.94 QALYs more than rehabilitation with an ICER of $754/QALY.
Makhni et al[22]	2016	RCR vs reverse TSA for large tears	Lifetime	RCR had a $15,500/QALY gain over nonoperative therapy and reverse TSA had a $37,400/QALY gain over nonoperation.
Makhni et al[26]	2016	Latarjet vs revision Bankart for recurrent shoulder instability	Lifetime	Latarjet had a 7.02 QALY gain ($1,941/QALY) gain over revision arthroscopic Bankart repair.
Ramme et al[31]	2016	Meniscal allograft vs partial meniscectomy for torn discoid meniscus	25 years	Meniscal allograft had incremental effectiveness gain of 4.80 QALYs with an ICER of $842/QALY compared to partial meniscectomy.
Samuelson et al[21]	2016	PRP in RCR	10 years	RCR with PRP is $6,775/QALY and without PRP is $6,612/QALY. No difference.
Mather et al[33]	2015	Meniscus tear diagnosis	5-10 years	H&P was most cost effective for degenerative tears For traumatic tears, MRI w/ H&P was preferred with ICER $40,565/QALY for GP and $10,631/QALY for orthopaedist,
Vavken et al[19]	2015	PRP in RCR	2 years	RCR with PRP had a difference of 0.0059 QALYS ($127,893/QALY) compared to without PRP.
Mather et al[34]	2014	Early vs late ACLR	Lifetime	Early group had an incremental gain of 0.28 QALYS over the delayed group, with a cost difference of $1,572.

FAI, Femoroacetabular impingement; RCR, rotator cuff repair; RTSA, reverse total shoulder arthroplasty; MRI, magnetic resonance imaging; US, ultrasound; AD-BT, arthroscopic debridement and biceps tenotomy; HA, hemiarthroplasty; PT, physical therapy; ACLR, anterior cruciate ligament reconstruction; TSA, total shoulder arthroplasty; PRP, platelet-rich plasma; H&P, history and physical; WTP, willingness to pay; GP, general practitioner; QALYS, quality-adjusted life years; ICER, incremental cost effectiveness ratio.

studies. An Apriori search algorithm combined the economic term "cost" with the following MeSH (PubMed Medical Subject Headings) terms related to sports medicine: "anterior cruciate ligament," "ACL," "posterior cruciate ligament," "PCL," "cartilage," "meniscus," "meniscal," "arthroscopy," "microfracture," "rotator cuff," "instability," "labrum," "tendon," "femoroacetabular impingement," and "FAI." The titles and abstracts were then reviewed to find the studies that met the inclusion and exclusion criteria. A review of the entire article was performed if there was still uncertainty.

The QHES instrument was used to evaluate the methodological quality of the CEA articles listed in this study.[17] QHES has been validated and used to evaluate economic studies in other fields of medicine, but it has rarely been used in orthopaedics. It consists of 16 criteria with "yes" or "no" weighted-questions. Each criterion has a point system ranging from 0 to 9, with "no" answers equating to 0 points. Overall scores range from 0 to 100, with 80 to 100 being considered a high-quality study and 50 or less being a low-quality study.[18]

Each study that met inclusion criteria was reviewed by two sports-medicine trained orthopaedic surgeons (CK and MH), and their quality was scored using QHES.[18] Any scoring disagreement was discussed, and the score was averaged if no resolution could be met between the two reviewers.

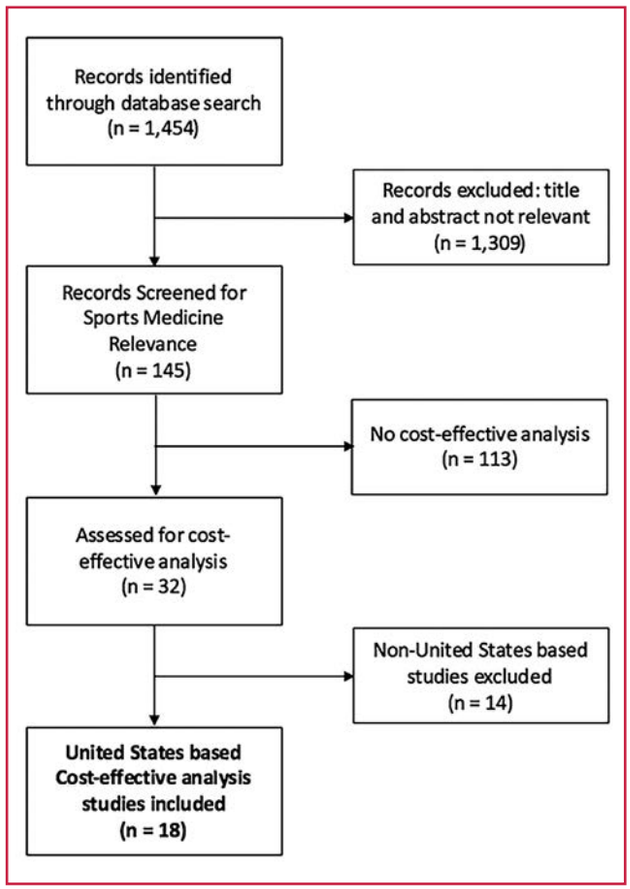

Figure 1. *Study flow diagram of studies meeting inclusion and exclusion criteria.*

RESULTS

The search algorithm identified 1,454 studies (Figure 1).[16] A total of 1,309 studies (90%) were not relevant to sports medicine. Of the remaining 145 studies, there were only 32 cost-effective analyses. When excluding the studies not performed in the United States, we found a total of 18 CEA studies to include in this review (Table 1). We reviewed the references of each of the 18 studies and did not find any further studies that met the inclusion criteria. There were various topics within the 18 studies, including rotator cuff tears (6 studies), meniscal tears (6 studies), anterior cruciate ligament reconstruction (2 studies), femoroacetabular impingement syndrome and hip arthroscopy (2 studies), and shoulder instability (2 studies).

The 18 studies had an average QHES score of 83.3 (range: 52-100), which showed excellent quality. Of the 16 QHES criteria, most were met in this review (Figure 2). All scores were agreed upon between the two reviewers except one, which was then averaged. The majority of the QHES criteria were met among the articles reviewed; however, some criteria were met by as few as four studies (Figure 2). Only 3 studies used randomized controlled-trials as their source of clinical outcome data. The majority of studies in this review also failed to explicitly state the magnitude and direction of potential biases.

Findings of the Included Studies

The majority of the CEA studies in this review focused on rotator cuff repairs (RCR) (n = 6). There were 2 studies that looked at the cost effectiveness of platelet rich plasma (PRP) in RCR. Vavken et al[19] found PRP with large rotator cuff tears insufficient to compensate for the tissue damage. In small and medium sized tears, the authors found PRP to possibly promote healing and decrease re-tear rates, but concluded that PRP was currently not cost effective for these tears. They found an incremental gain of only 0.0059 quality adjusted life years (QALYs) compared to RCR without PRP, resulting in an incremental cost-effectiveness ratio (ICER) of $127,893 per QALY.[19] This was in contrast to typical United States' intervention thresholds of $50,000 to $100,000 per QALY.[20] Similarly, a study by Samuelson et al[21] showed no difference in cost effectiveness between RCR with PRP and RCR without PRP.

Two studies compared the economic impact between RCR and total shoulder arthroplasty (RTSA). Makhni et al[22] compared arthroscopic RCR with primary RTSA and nonoperative management in patients with symptomatic large and massive tears. Both RCR and RTSA had a QALY gain over nonoperative treatment (0.71 and 0.7, respectively). Despite the high re-tear rate, initial RCR was found to be more cost effective than RTSA. Dornan et al[23] evaluated treatment options for massive rotator cuff tears in patients with pseudoparalysis and non-arthritic shoulders. Arthroscopic RCR with conversion to RTSA on potential

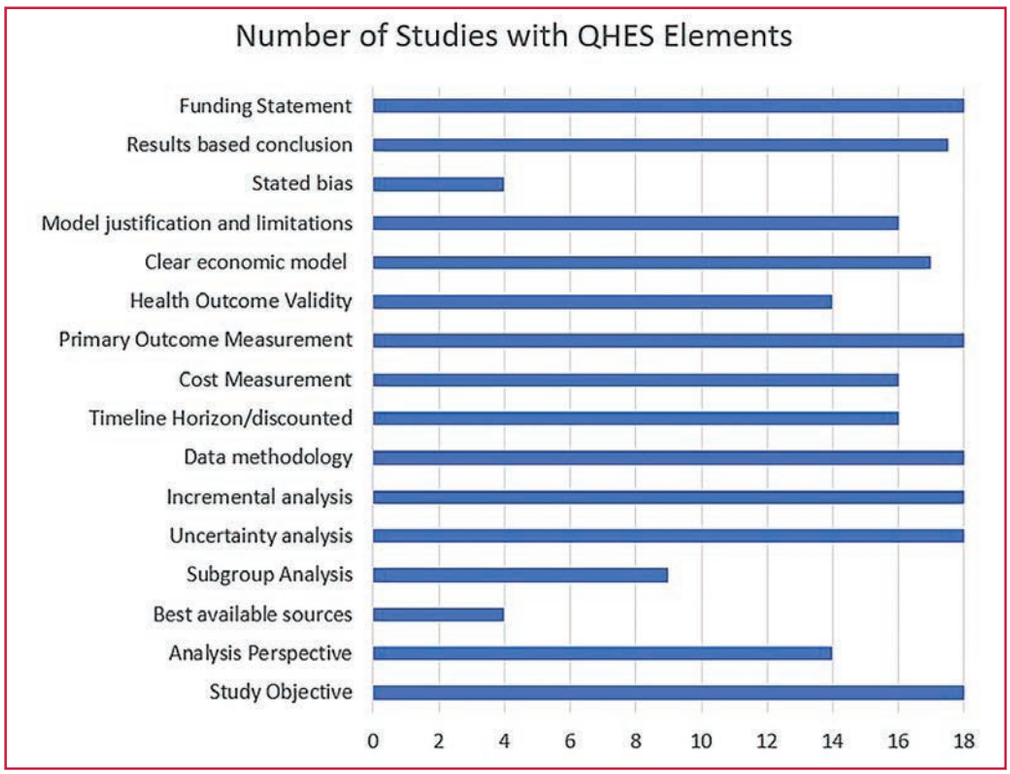

Figure 2. *The number of studies that satisfy each of the Quality of Health Economic Studies instrument components.*

failure was found to be the most cost-effective strategy. Revision arthroscopic RCR after a failed initial RCR was less cost effective. Kang et al[24] evaluated massive and irreparable rotator cuff tears and found RTSA to be the preferred and most cost-effective method compared to a repair, specifically for the elderly population. Arthroscopic debridement with biceps tenotomy was a cheaper option for pain relief but lacked any functional improvement.

A study by Gyftopoulos et al[25] compared magnetic resonance imaging (MRI) and ultra-sound imaging for full-thickness supraspinatus tears. Both MRI and ultra-sound imaging were found to be cost effective in full-thickness supraspinatus tears that were symptomatic. Based on the cost-effective criteria, the results indicated MRI to be the preferred strategy. Regarding shoulder instability, Makhni et al[26] performed a study on recurrent instability that compared Latarjet to revision arthroscopic repair. The Latarjet procedure showed lower cost and improved clinical outcomes over revision arthroscopy and nonoperative treatment. Min et al[27] found both open Latarjet and arthroscopic Bankart to be cost effective.

There were 6 studies that focused on meniscal tears. The economic effect between meniscal repair and partial meniscectomy was evaluated by both Rogers et al[28] and Feeley et al.[29] Meniscal repair was found to be a cost-effective strategy despite having substantially higher failure rates. For ACL reconstruction, Lester et al[30] found a meniscus repair to be more cost effective than a meniscectomy.

Using a study population of young-adult women, Ramme et al[31] looked at meniscal allografts for discoid lateral meniscus tears. The model showed that although initially more costly, meniscal allografts were more effective in delaying a total knee replacement than partial meniscectomy. Bendich et al[32] determined that meniscus allograft transfers are not currently cost effective, but younger and non-obese patients are closer to the threshold. When looking at the cost effectiveness for the diagnosis of meniscal tears, Mather et al[33] found a patient history and physical examination to be the most cost effective for degenerative tears. Additionally, an MRI to confirm patient history and physical examination was their preferred method for diagnosing traumatic tears, with orthopaedic surgeons having a lower incremental cost-effective ratio than general practitioners.

Two studies looked at the economic effect of ACL reconstruction. Mather et al[34] evaluated the difference between QALYs of early versus late ACL reconstruction. From a societal health-system perspective, early ACL reconstruction (ie, < 10 weeks) was found to be more cost effective than rehabilitation with optional delayed ACL reconstruction. When evaluating ACL reconstruction in competitive athletes, Stewart et al[35] found surgery to be the most cost effective with the highest return-to-play rate.

Two studies by Cunningham et al[36] and Lodhia et al[37] focused on the hip. When examining the cost effectiveness of femoroacetabular impingement (FAI), Cunningham et al[36] found that advanced imaging

was not as cost effective as the willingness to pay (ie, threshold > $50,000/QALY). For the general practitioner, patient history and physical examination with radiographs and diagnostic injections were preferred compared to advanced imaging. While studying the economic impact of acetabular labral tears, Lodhia et al[37] found hip arthroscopic surgery to have a considerably lower incidence of symptomatic osteoarthritis. Additionally, hip arthroscopic surgery was found to be more cost effective than rehabilitation alone for symptomatic labral tears.

DISCUSSION

The number of CEA studies in sports medicine has increased over the past several years. Since the 2014 systematic review with 16 studies, there have been 18 new publications. Similar to the 2014 review, investigation procedures discussed in this study focused mainly on rotator cuff and ACL. However, this review additionally focuses on diagnostic tests and other treatment options to fully grasp the breadth of cost effectiveness in sports medicine, which in part explains the increase in recent CEA studies. Physicians and policy makers can apply this increased economic knowledge toward the complex problem of rising healthcare expenditure.[2]

This study and the 2014 systematic review showed that cost-effective surgeries included ACL reconstruction, RCR, hip arthroscopic surgery, shoulder instability surgery, and autologous chondrocyte implantation.[24] In this study, quality assessment showed the overall studies were of reasonable quality. However, it concluded that careful attention needed to be paid to the methodology of CEA research for future sports-medicine publications.[3]

Other orthopaedic subspecialties are also actively researching cost effectiveness within their respective fields.[7,38-40] Within orthopaedics, a systematic review over spine literature is the largest review to date.[39] The authors identified 33 CEA studies between 1976 and 2010 and did not limit their research to only United States studies, which can potentially limit generalizability. Various studies have also commented on the lack of cost-analysis literature within orthopaedics.[7,38,40] As this review demonstrates, sports-medicine researchers are actively working to answer these concerns and determine cost effectiveness within the field.

The quality of CEA studies presented in this review ranges from moderate to excellent methodology and data reporting. The majority of studies in this review had excellent methodology in terms of models, cost measurements, and analyses. Overall, the study's methodology is acceptable. However, high quality sources (eg, RCTs) are lacking for clinical outcome data. Future CEA studies will aim to use RCT data to improve the validity of their results, but this will be reliant on more high-quality primary trials being performed, especially in the United States. Explicitly stating the direction and magnitude of potential biases will also improve the reporting and quality of CEA studies. The QHES instrument is a simple and reliable tool to score CEA studies and should be used as a reference for researchers conducting cost-effectiveness studies.

There are a number of limitations within this review. The breadth of CEA studies within sports medicine remains limited. This review shows the focus has been on RCR, ACL reconstructions, meniscus surgery, and FAI. There is also a lack of CEA randomized control trials in sports medicine. Having more randomized control trials will lead to further decreased bias, which has proved deficient in this review. Although a thorough review of multiple databases and relevant references was performed, it is possible that our literature search did not find all relevant CEA studies within sports medicine. The QHES instrument was designed to assess the methodology of CEA studies, but it mainly focuses on the quality of reporting information. A study did not receive a qualifying score if it did not explicitly state one aspect of the scoring instrument or it could not be easily implied. This results in the lack of clarity with the study's methodology and not necessarily a lack in the methodology itself. QHES scores were also susceptible to subjective bias, although this was limited by having two authors independently score each study.

CONCLUSION

Within sports medicine, there has been an increasing number of CEA studies published over the past several years. However, the breadth of studied conditions is still limited and there are many areas of sports medicine that lack cost-effectiveness evaluation. The overall quality of recent studies as a whole is excellent, although widely variable. To improve quality of future studies, authors should continue to be critical of data reporting and improving methodology. To fully understand cost effectiveness within sports medicine, further high-quality research spanning a greater breadth of conditions is still needed.

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