Article Type: Meta-Analysis

Title: Optimal Surveillance Colonoscopy Intervals Following Adenoma Removal: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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CLINICAL QUESTION BOX

In adults following complete colorectal adenoma removal, should more-intensive or less-intensive surveillance colonoscopy be recommended?

Randomized evidence shows that more-intensive surveillance increases detection of advanced colorectal neoplasia and adenomas. These findings support considering more-intensive surveillance to increase lesion detection. However, a reduction in colorectal cancer incidence has not been demonstrated, and the available evidence does not establish equivalence between strategies across all risk groups. Surveillance intervals should therefore be individualized according to baseline neoplasia risk and colonoscopy quality.

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ABSTRACT

Background: The optimal interval for surveillance colonoscopy after adenoma removal remains uncertain. We compared more-intensive with less-intensive surveillance in randomized trials.

Methods: We searched MEDLINE, Embase, CENTRAL, and Web of Science through October 2026 for randomized trials comparing post-polypectomy surveillance intervals. Random-effects meta-analyses evaluated advanced colorectal neoplasia, colorectal cancer incidence, adenoma detection, and serious adverse events using risk ratios (RRs) or risk differences (RDs), with 95% confidence intervals (CIs). Evidence certainty was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.

Results: Six reports describing eight randomized comparisons (16,077 participants) were included. More-intensive surveillance increased the detection of advanced colorectal neoplasia (RR, 1.18; 95% CI, 1.05 to 1.32), but the difference was not significant after excluding EPoS II (RR, 0.89; 95% CI, 0.62 to 1.28). Colorectal cancer occurred in 26 versus 33 participants, with no significant difference between strategies (RD, −0.03 percentage points; 95% CI, −0.23 to 0.17). Adenoma detection was higher with more-intensive surveillance (RR, 1.36; 95% CI, 1.31 to 1.41). No significant difference in serious adverse events was observed (RR, 1.11; 95% CI, 0.39 to 3.19). GRADE certainty was moderate for advanced colorectal neoplasia and colorectal cancer incidence, high for adenoma detection, and low for serious adverse events.

Conclusions: More-intensive surveillance increased detection of advanced colorectal neoplasia and adenomas, without a demonstrated reduction in colorectal cancer incidence. These findings support considering more-intensive surveillance for lesion detection, while surveillance intervals should be individualized.

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Keywords: Colonoscopy; Colorectal Neoplasms; Adenomatous Polyps; Surveillance Intervals; Polypectomy; Meta-Analysis.

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INTRODUCTION

Colorectal cancer represents a substantial global public health and economic burden. According to GLOBOCAN 2024 estimates, approximately 2.04 million new colorectal cancer cases and 918,000 deaths occurred worldwide, making colorectal cancer the third most frequently diagnosed cancer and the second leading cause of cancer-related mortality.[1] In the United States, annual colorectal cancer-related medical expenditures were projected to reach $24.3 billion in 2020, accounting for approximately 11.6% of total cancer care expenditures.[2] Colonoscopy enables the detection and removal of precancerous lesions. However, optimizing postpolypectomy surveillance is equally important to minimize unnecessary procedures, reduce healthcare costs, and improve resource utilization.

After colorectal adenoma removal, surveillance colonoscopy is recommended to detect metachronous neoplasia. However, the optimal surveillance interval remains uncertain, with substantial variation across international guidelines. For patients with one or two small (<10 mm) nonadvanced adenomas, recommended surveillance intervals range from 7–10 years in the United States to 3–5 years in Japan and 5–10 years in Korea,[3-5] whereas European and British guidelines favor returning to routine screening.[6,7] More recent recommendations from Alberta, Canada, favor fecal immunochemical testing after 5 years for this low-risk population.[8] In contrast, approximately 3-year surveillance is commonly recommended for higher-risk adenomas, although the criteria defining high risk vary across guidelines. These discrepancies highlight persistent uncertainty regarding the optimal balance between surveillance intensity, clinical benefits, and procedural burden.

The evidence supporting current surveillance recommendations remains limited, with the certainty of evidence varying across risk categories. Several systematic reviews and meta-analyses have evaluated postpolypectomy outcomes. A meta-analysis involving 811,181 participants summarized colorectal cancer incidence according to baseline adenoma risk and

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follow-up interval,[9] while a more recent meta-analysis of 11 observational studies evaluated advanced neoplasia detection at second surveillance colonoscopy.[10] Although these findings support risk-stratified surveillance, they provide limited direct evidence from randomized comparisons of surveillance intervals. Recent randomized evidence has strengthened the evaluation of colorectal cancer incidence,[11] but uncertainty remains regarding the benefits and harms of different surveillance intensities across patient populations.

This systematic review and meta-analysis aimed to compare the efficacy and safety of more-intensive versus less-intensive surveillance after colorectal adenoma removal using evidence from randomized controlled trials (RCTs).

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METHODS

Study Design and Eligibility

This systematic review and meta-analysis was conducted following methodological guidance from the Cochrane Handbook for Systematic Reviews of Interventions and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.[12,13] The review protocol was registered in PROSPERO (CRD420261530836).

RCTs were eligible if they enrolled adults aged 18 years or older who had undergone endoscopic removal of colorectal adenomas and compared at least two predefined colonoscopic surveillance schedules. No restrictions were imposed on baseline adenoma number, size, histological characteristics, or risk classification. Nonrandomized studies and trials evaluating colorectal cancer screening rather than postpolypectomy surveillance were excluded. Trials primarily addressing local recurrence after piecemeal resection of large colorectal lesions or surveillance in patients with serrated polyposis syndrome were also excluded because these represented distinct clinical settings.

Information Sources

MEDLINE (via PubMed), Embase (via Ovid), the Cochrane Library, and Web of Science Core Collection were systematically searched from inception through October 10, 2026, without language restrictions. The search strategy combined terms related to colorectal adenomas, polypectomy, colonoscopic surveillance, surveillance intervals, and randomized controlled trials. Reference lists of eligible studies, relevant systematic reviews, and clinical practice guidelines were manually screened to identify additional studies. Detailed database-specific search strategies and corresponding search results are provided in Supplementary Table S1.

Study Selection and Data Extraction

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Following removal of duplicate records, two reviewers (H.S. and S.Y.) independently screened titles and abstracts and assessed the full texts of potentially eligible studies. Disagreements were resolved through discussion or consultation with a third reviewer (M.K.).

The same two reviewers independently extracted information on study design, sample size, baseline adenoma characteristics, surveillance schedules, follow-up duration, and outcome-specific event counts and denominators using a standardized extraction form. Multiple publications from the same trial were reviewed collectively to avoid duplicate data inclusion. Independently randomized cohorts within a trial were treated as separate comparisons for neoplasia and cancer outcomes and combined for serious adverse events when appropriate. Nonrandomized cohorts were excluded from the quantitative synthesis.

Outcomes

Within each trial, randomized groups were classified according to surveillance intervals and examination frequency. Groups with earlier or more frequent colonoscopies were classified as more-intensive surveillance, whereas those with longer intervals or fewer examinations were classified as less-intensive surveillance. The primary outcomes were colorectal cancer incidence and advanced colorectal neoplasia. Secondary outcomes were adenoma detection and serious adverse events. Trial-specific outcome definitions and assessment periods were recorded. Patient-level outcomes and procedure-related complications were analyzed separately, using outcome-specific denominators when available.

Risk of Bias and Certainty of Evidence

Two reviewers independently assessed the risk of bias for each outcome using the revised Cochrane Risk of Bias tool for randomized trials (RoB 2).[14] The assessment covered five domains: the randomization process, deviations from intended interventions, missing outcome

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data, outcome measurement, and selection of reported results. Disagreements were resolved through discussion.

The certainty of evidence for each outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias.[15]

Statistical Analysis

Binary outcomes were synthesized using inverse-variance random-effects meta-analysis. Risk ratios (RRs) with 95% confidence intervals (CIs) were calculated for advanced colorectal neoplasia, adenoma detection, and serious adverse events, whereas risk differences (RDs) were used for colorectal cancer incidence because of the low event frequency. Between-study variance was estimated using the DerSimonian–Laird method, and statistical heterogeneity was assessed using the I^2 statistic and Cochran Q test.[16,17]

For the European Polyp Surveillance (EPoS) II trial, observed event counts rather than published inverse-probability-weighted estimates were used to derive unadjusted effects on the same scale as those from the other trials. Subgroup analyses were conducted according to follow-up duration (approximately 3, 4, and 5 years). A sensitivity analysis excluding EPoS II was performed to assess the robustness of the pooled estimate for advanced colorectal neoplasia. All statistical analyses were performed using R version 4.4.1 with the meta package.[18]

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RESULTS

Study Selection and Trial Characteristics

A total of 2,995 records were identified through database searches. After removing 317 duplicates, 2,678 records underwent title and abstract screening, of which 2,589 were excluded. The remaining 89 reports underwent full-text assessment, and 83 were excluded. Ultimately, six reports describing randomized trials were included in the systematic review and meta-analysis (Figure S1).

The six reports described eight randomized comparisons involving 16,077 participants, with comparison sample sizes ranging from 73 to 10,799. The studies were conducted in the United States, Japan, Denmark, and eight European countries. Baseline adenoma characteristics, patient risk profiles, surveillance protocols, and colonoscopy quality standards varied across trials. More-intensive surveillance involved earlier or additional colonoscopies, whereas less-intensive surveillance involved longer intervals or fewer scheduled examinations. Surveillance intervals ranged from 6 months to 5 years, with differences in follow-up duration and outcome assessment. The characteristics of the included trials are summarized in Table 1.[11,19-23]

Advanced Colorectal Neoplasia

Six randomized comparisons involving 14,223 participants contributed to this analysis. Advanced colorectal neoplasia or advanced adenomas were detected in 564 of 7,034 participants (8.02%) assigned to more-intensive surveillance and 483 of 7,189 (6.72%) assigned to less-intensive surveillance. More-intensive surveillance was associated with a significantly higher detection rate (pooled RR, 1.18; 95% CI, 1.05–1.32; $I^2 = 0\%$; Figure 1). Subgroup analyses by surveillance horizon yielded RRs of 0.90 (95% CI, 0.52–1.53) at 3 years, 0.95 (95% CI, 0.52–1.72) at 4 years, and 1.19 (95% CI, 0.99–1.43) at 5 years, without significant differences between subgroups (P = 0.50; Table S2).

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The EPoS II trial contributed 89.7% of the pooled statistical weight, with advanced adenomas detected in 513 of 5,397 participants in the more-intensive group and 421 of 5,389 in the less-intensive group (RR, 1.22; 95% CI, 1.08–1.38). After excluding EPoS II, advanced lesions were detected in 51 of 1,637 and 62 of 1,800 participants, respectively, with no statistically significant difference between surveillance strategies (pooled RR, 0.89; 95% CI, 0.62–1.28; I^2 = 0%; Figure S2).

Colorectal Cancer Incidence

Six randomized comparisons involving 14,043 participants reported colorectal cancer incidence. Colorectal cancer occurred in 26 of 6,941 participants (0.37%) assigned to more-intensive surveillance and 33 of 7,102 (0.46%) assigned to less-intensive surveillance. No statistically significant difference was observed between the two strategies (pooled RD, −0.03 percentage points; 95% CI, −0.23 to 0.17; I^2 = 0%; Figure 2).

Subgroup analyses showed no statistically significant differences at the 3-, 4-, or 5-year surveillance horizons (Table S2). However, one smaller Danish randomized comparison reported more colorectal cancer cases with 4-year than with 2-year surveillance.

Adenoma Detection

Six randomized comparisons involving 14,043 participants contributed to the analysis of adenoma detection. The cumulative detection rate was 51.06% (3,544/6,941) in the more-intensive surveillance group and 37.55% (2,667/7,102) in the less-intensive surveillance group. More-intensive surveillance was associated with significantly higher cumulative detection (pooled RR, 1.36; 95% CI, 1.31–1.41; I^2 = 0%; Figure 3).

Subgroup analyses by follow-up duration yielded RRs of 1.32 (95% CI, 1.19–1.45), 1.21 (95% CI, 0.97–1.50), and 1.37 (95% CI, 1.31–1.43) at approximately 3, 4, and 5 years, respectively.

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The differences were statistically significant in the 3- and 5-year subgroups but not in the 4-year subgroup (Table S2).

Serious Adverse Events

Two reports involving 11,730 participants contributed to the analysis of patient-level serious adverse events. Events occurred in 25 of 5,872 participants (0.43%) assigned to more-intensive surveillance and 27 of 5,858 (0.46%) assigned to less-intensive surveillance. The pooled analysis showed no statistically significant difference between groups (RR, 1.11; 95% CI, 0.39–3.19; $I^2 = 55\%$; Figure 4).

Risk of Bias and Certainty of Evidence

Outcome-specific RoB 2 assessments indicated low risk of bias or some concerns, primarily related to missing outcome data and deviations from assigned surveillance schedules. No assessment was rated as having a high risk of bias (Figures S3–S6). Formal assessment of publication bias was not performed because fewer than 10 studies contributed to each outcome. The GRADE certainty of evidence was moderate for advanced colorectal neoplasia and colorectal cancer incidence, high for adenoma detection, and low for serious adverse events (Table S3). Certainty was downgraded for indirectness for advanced colorectal neoplasia, imprecision for colorectal cancer incidence, and inconsistency and imprecision for serious adverse events.

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DISCUSSION

In this systematic review and meta-analysis of RCTs, more-intensive post-polypectomy surveillance was associated with higher detection of advanced colorectal neoplasia and adenomas, without statistically significant differences in colorectal cancer incidence or serious adverse events. These findings support a risk-adapted approach rather than uniformly shortening surveillance intervals. For patients with high-risk adenomas, surveillance at both 3 and 5 years may increase cumulative lesion detection compared with surveillance at 5 years alone. Conversely, after complete baseline adenoma clearance, routinely adding a 1-year examination to surveillance at 3 years offers no consistent advantage in advanced colorectal neoplasia detection. These schedule-specific recommendations should be interpreted within the populations and follow-up periods studied.

Cumulative lesion detection is partly determined by the opportunity to observe lesions. An additional colonoscopy may identify and remove abnormalities before a common follow-up examination, contributing to greater cumulative detection without necessarily indicating differences in underlying neoplasia development. Consequently, adenoma detection and advanced colorectal neoplasia may show different responses to an additional examination. Because the included trials did not consistently report outcomes separately at each scheduled colonoscopy, the incremental yield attributable to individual examinations could not be reliably compared across studies. Observational data also show that advanced-neoplasia detection at individual surveillance examinations varies with the interval since polypectomy, underscoring the distinction between per-examination and cumulative yield.[24]

The differences among trial designs help explain why the additional diagnostic yield was inconsistent. The National Polyp Study and Japan Polyp Study evaluated a 1-year examination added to surveillance at 3 years; the Japanese trial also used a two-round baseline colonoscopy to clear neoplastic lesions.[23] Tandem-colonoscopy evidence further indicates that adenomas

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may be missed at the initial examination, making the thoroughness of baseline assessment relevant to subsequent detection.[25] Under these conditions, an early additional examination may have limited opportunity to detect advanced lesions. In contrast, EPoS II enrolled patients with high-risk adenomas and compared examinations at 3 and 5 years with an examination at 5 years alone, after complete polyp removal, cecal intubation, and adequate bowel preparation. A later additional examination in a higher-risk population may yield more detectable lesions. However, these explanations arise from differences between trials and do not establish surveillance timing or baseline risk as independent effect modifiers.

Clinical application should consider the likelihood that an additional colonoscopy will detect advanced lesions rather than adenomas alone. Baseline adenoma characteristics, completeness of resection, and colonoscopy quality are relevant when judging whether trial findings apply to an individual patient. A large observational cohort also found that baseline polyp characteristics and colonoscopy quality were associated with subsequent neoplasia risk.[26] Evidence from serial-surveillance cohorts also indicates that findings at the first surveillance colonoscopy can refine subsequent advanced-neoplasia risk beyond baseline findings alone.[10] These observational data do not establish an optimal examination interval. The incremental detection achieved by additional surveillance must be weighed against procedure burden, potential overdiagnosis and unnecessary treatment, and subsequent surveillance. Moreover, the absence of a significant pooled difference in colorectal cancer incidence does not establish equivalence; the noninferiority finding from EPoS II is specific to its prespecified margin and interim analysis.[11] Surveillance intervals should also account for healthcare resource availability and endoscopy capacity. Risk-adapted surveillance may help allocate endoscopy resources, although these trials do not establish an individualized surveillance algorithm.[27]

Several limitations warrant consideration. First, the pooled estimate for advanced colorectal neoplasia was largely driven by EPoS II and was not robust to its exclusion. Second, differences

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in lesion definitions, baseline colonoscopy quality, surveillance adherence, and examination schedules may limit the comparability of trials despite low statistical heterogeneity. Subgroup analyses by follow-up duration could not establish optimal surveillance intervals. Third, the use of available-case or per-protocol populations in some trials may have introduced selection bias, while the use of aggregate event counts limited the ability to account for missing outcome data and differences in individual follow-up duration. Fourth, the small numbers of colorectal cancer events and serious adverse events limited the precision of the pooled estimates, and longer-term clinical outcomes, particularly colorectal cancer mortality, remain uncertain. Finally, publication bias could not be reliably assessed because fewer than 10 studies contributed to each outcome.

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CONCLUSIONS

More-intensive post-polypectomy surveillance increases detection of advanced colorectal neoplasia and adenomas. The finding for advanced colorectal neoplasia was largely driven by one large trial. A reduction in colorectal cancer incidence has not been demonstrated. These findings support considering more-intensive surveillance for lesion detection, with intervals individualized according to patient risk and colonoscopy quality. Further studies are needed to clarify optimal surveillance intervals and procedural safety.

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Ethics Approval and Consent to Participate

Not applicable.

Availability of Data and Materials

Data are available in the article and supplementary materials. Raw data are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare no competing interests.

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Authors' Contributions

Conceptualization, H.S. and M.I.; Methodology, H.S. and M.I.; Formal Analysis, H.S. and S.Y.; Data Curation, H.S., S.Y., and M.K.; Writing—Original Draft Preparation, H.S.; Writing—Review & Editing, H.S., S.Y., M.K., R.A., and M.I.; Supervision, A.A. and M.I. All authors reviewed and approved the final manuscript and agreed to be accountable for the work.

Generative AI Declaration

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with manuscript drafting, organization, and language editing. The authors subsequently reviewed and edited the content as necessary and assume full responsibility for the accuracy and integrity of the published work.

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TABLES Table 1. Characteristics of randomized controlled trials included in the systematic review and meta-analysis.

Study	Country	Patients, n	Age, years	Male, n (%)	More-intensive surveillance	Less-intensive surveillance	Follow-up
Kronborg et al., 1983	Denmark	156	NR	NR	Every 6 months	Every 2 years	4 years
Winawer et al., 1993	USA	1,418	61.2 ± 10.2	993 (70.0)	1 and 3 years	3 years	3 years
Kronborg et al., 2006 (A/B)	Denmark	671	NR	383 (57.1)	Every 2 years	Every 4 years	8.8 years
Kronborg et al., 2006 (C/D)	Denmark	73	NR	38 (52.1)	Every 6 months	Every 1 year	10.3 years
Kronborg et al., 2006 (E/F)	Denmark	200	NR	108 (54.0)	Every 1 year	Every 2 years	5.2 years
Lieberman et al., 2007	USA	594	62.5 ± 7.1	NR	2 and 5 years	5 years	5–5.5 years
Matsuda et al., 2021	Japan	2,166	58.5 ± 7.1	1,432 (66.1)	1 and 3 years	3 years	3 years
Jover et al., 2026	International	10,799	62.2 ± 6.8	7,041 (65.2)	3 and 5 years	5 years	5–5.5 years

NR, not reported; USA, United States of America

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FIGURE LEGENDS

Figure 1. Advanced colorectal neoplasia after more-intensive versus less-intensive surveillance colonoscopy.

Figure 2. Colorectal cancer incidence after more-intensive versus less-intensive surveillance colonoscopy.

Figure 3. Adenoma detection after more-intensive versus less-intensive surveillance colonoscopy.

Figure 4. Serious adverse events after more-intensive versus less-intensive surveillance colonoscopy.

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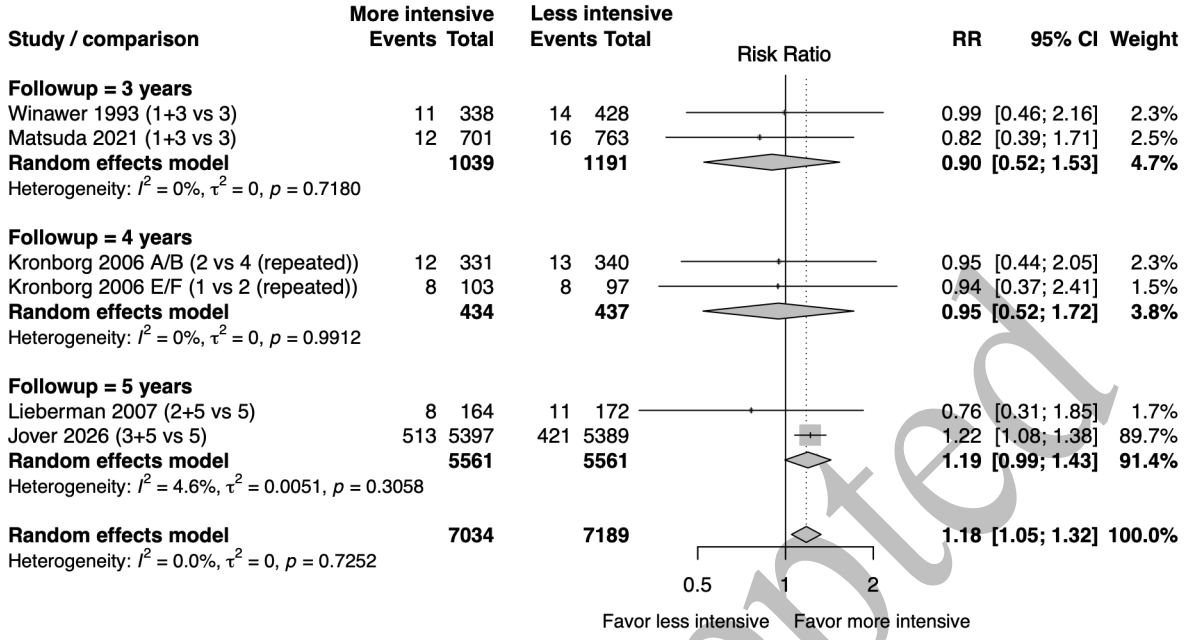

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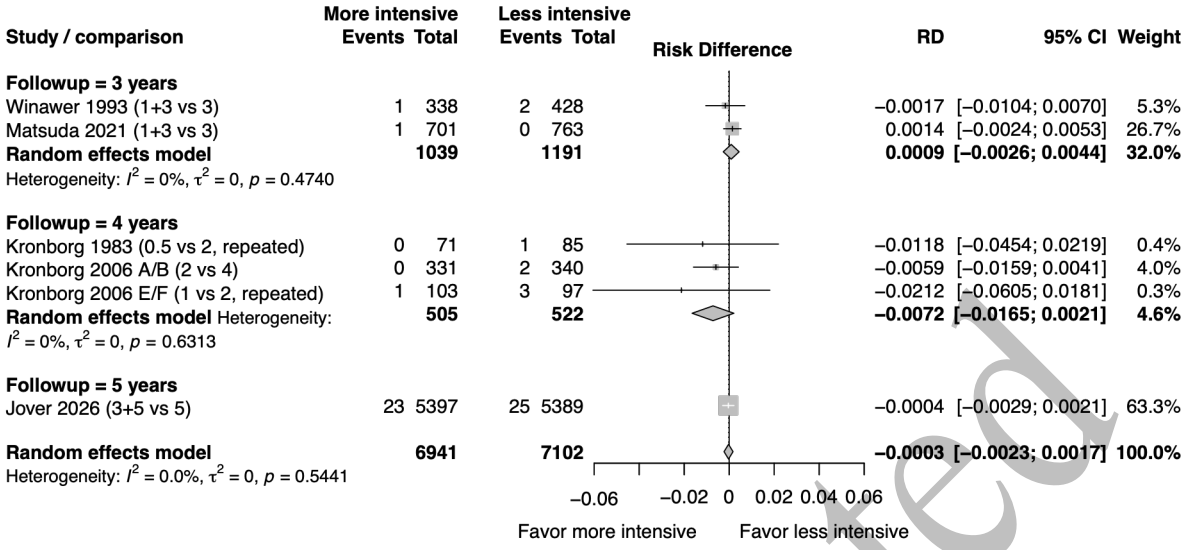

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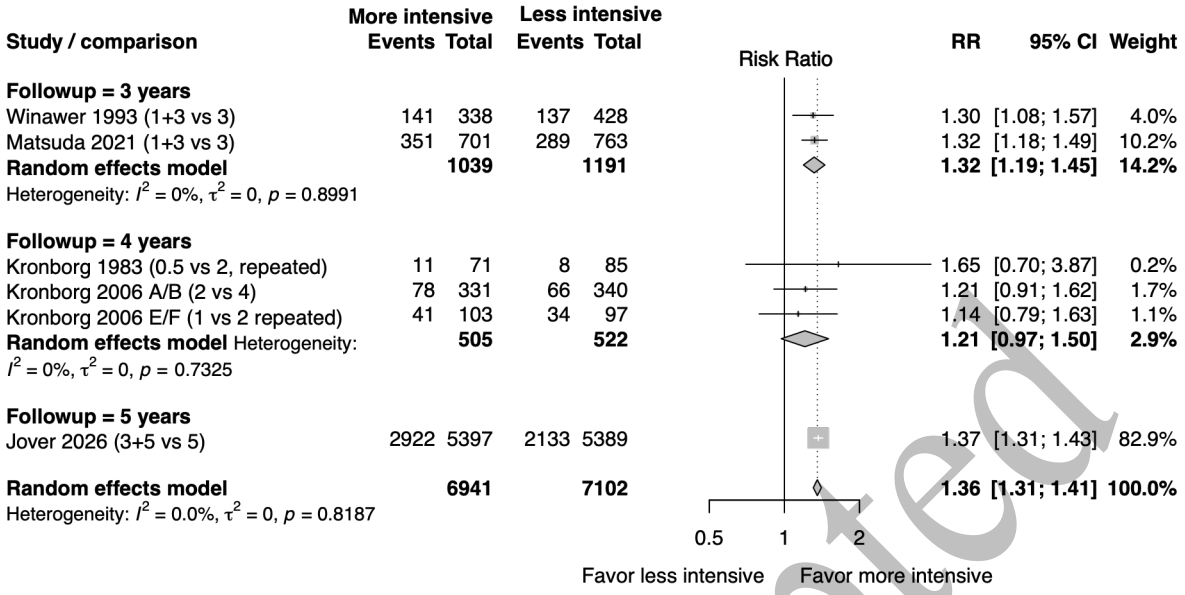

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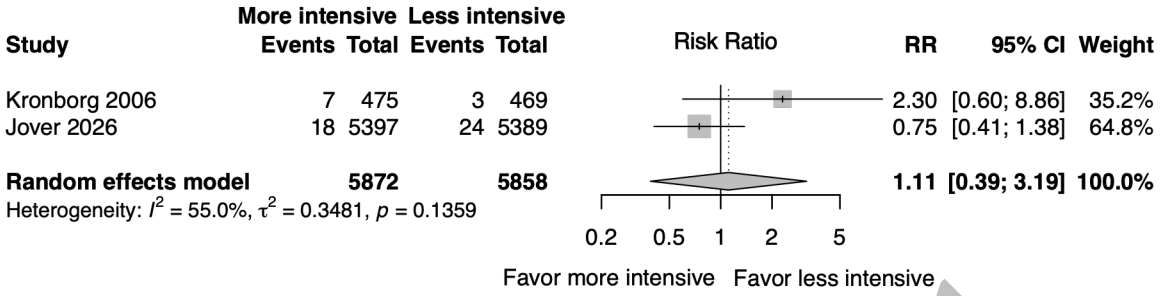

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