

Research Article

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Motor Recovery and Readiness for Mobilization After Spinal Anesthesia

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ABSTRACT

Background: Recovery after spinal anesthesia can be described through motor-block regression, readiness to mobilize, observed walking and discharge readiness. These outcomes need separate definitions when evidence is mapped across anesthetic studies.

Objective: To map the definitions, instruments, assessment schedules and functional criteria used to evaluate motor recovery and readiness for mobilization after spinal anesthesia in lower-limb surgery, with a focus on ambulatory care.

Methods: PubMed was searched during 12–24 September 2026 using an unchanged strategy and no search filters. The search yielded 3,729 records. Two reviewers independently screened titles and abstracts and assessed full texts, with their decisions concealed from one another until comparison. Data were extracted by one reviewer and verified by the second. Eligibility criteria were refined during screening, and earlier decisions were rechecked against the final criteria. Of 38 full-text reports assessed, 14 were included. A descriptive synthesis mapped motor recovery, mobilization and discharge separately. No prospective written protocol, registration or structured critical appraisal was used.

Results: The 14 included reports were published between 2006 and 2022; 11 concerned knee arthroscopy and three concerned other or mixed lower-limb procedures. Retrieved methods showed differences in Bromage coding, recovery thresholds, assessment frequency and timing origins. One study assessed motor function using a 1-to-6 scale, whereas others used 0-to-3 versions. Several reports distinguished motor recovery from walking; one explicitly scheduled walking attempts after sensory and motor resolution. Other reports emphasized motor recovery and discharge without establishing a separate walking assessment in the material inspected. Targeted re-examination also identified sensory-recovery criteria, sitting tolerance, sedation assessment and routine hemodynamic monitoring. One report tabulated toe-proprioception recovery with limited procedural detail. A linked protocol also included functional ambulation scoring and optional Romberg testing, without confirming which alternative was used in practice. Routine monitoring was distinguished from explicit orthostatic testing.

Conclusion: Motor recovery, readiness to mobilize, observed walking and discharge represent distinct outcomes. The included reports show substantial variation in their definitions and assessment schedules. Consequently, comparisons require attention to scale anchors, timing origins and functional criteria. The single-database search and absence of structured critical appraisal limit the breadth and strength of the conclusions.

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Introduction

Anesthesia research in ambulatory lower-limb surgery frequently examines how quickly patients recover after intrathecal local anesthetics. However, the term recovery can refer to different events. Some studies prioritize complete regression of motor block, others record the first successful mobilization, and others report readiness for discharge or actual departure from hospital. The selected trials provide examples of these different approaches [1-5]. Consequently, understanding which event was measured is necessary before interpreting a reported recovery time.

In this context, motor assessment is particularly relevant to the relationship between anesthesiology and rehabilitation. It describes the return of movement after neuraxial blockade, while mobilization concerns performance of an activity such as sitting, standing or walking. A motor score can form part of a mobilization decision, but the score and the activity are not interchangeable measurements. Kahn and colleagues assessed block resolution before repeated walking attempts, while Breebaart and colleagues separated partial motor regression, complete recovery, ambulation and discharge [2,5]. Taken together, these studies illustrate why an assessment-focused review could add information beyond a comparison of anesthetic drugs.

Building on this distinction, the present work asks: How are motor recovery and readiness for mobilization defined, measured and reported following spinal anesthesia in adults undergoing ambulatory lower-limb surgery? This review maps the tools, thresholds, timing conventions and functional criteria used, rather than rank anesthetic regimens. Scoping-review methods are suitable for organizing these heterogeneous concepts and identifying areas requiring more detailed investigation [6,7].

Nevertheless, related reviews already exist. A 2025 scoping review addresses anesthesia and analgesia in outpatient hip and knee arthroplasty, while a 2025 network meta-analysis compares spinal local anesthetics for ambulatory non-arthroplasty surgery [8,9]. Accordingly, the contribution of this review is a focused map of assessment definitions, instruments, timing and functional criteria. This focus is not a claim that no earlier assessment-focused review exists. The present synthesis does not estimate the prevalence of assessment practices throughout the literature.

Methods

Review Design and Protocol

This scoping review maps assessment methods rather than comparative anesthetic efficacy. Reporting was guided by PRISMA-ScR, while the Population–Concept–Context framework informed the scope [6, 7]. No prospective written protocol was prepared, and the review was not registered. Although PROSPERO does not accept scoping reviews, this eligibility restriction does not preclude protocol registration through other repositories [10]. Eligibility criteria were developed and refined during screening; consequently, earlier decisions were rechecked against the final criteria.

Information Source and Search Strategy

PubMed was the sole database used to identify eligible reports. It was selected as the information source for this bounded review because the objective was to map recovery concepts and outcome definitions rather than provide an exhaustive comparative synthesis of anesthetic drug efficacy; this choice limits the completeness of the evidence map. Searches were conducted during 12–24 September 2026, with the last search on 24 September. The same Boolean strategy combined spinal-anesthesia terms with motor-recovery, walking, mobilization and discharge-readiness terms. No language, date, age or full-text-availability filters were applied. The complete query is reproduced in Appendix C. The search set contained 3,729 records; subsequent searches during this period added no records to that set. No duplicate records were removed.

All 14 included reports were identified through PubMed. Other databases and citation searches did not contribute additional records to the selection flow. Registries, a linked original protocol and thesis reproductions were used only to clarify or retrieve information for included publications, and were not counted as additional included studies [11–15].

Eligibility and Study Selection

The review focused on adults receiving single-shot spinal anesthesia for ambulatory lower-limb surgery and on studies assessing motor recovery or readiness for mobilization. Relevant measurements included motor-scale recovery, sensory or functional prerequisites for mobilization, observed ambulation and discharge measures related to recovery. Reports focused on surgical procedures or medical devices without assessing motor recovery or readiness for mobilization after spinal anesthesia were outside the scope. Reports lacking relevant motor or mobilization outcomes, involving an inpatient or non-day-case setting, or using

another anesthetic technique were excluded. No restriction to a particular intrathecal drug was imposed.

Following the initial screening and verification process, Asad Ashoor and Wesam Qurban completed independent assessment of all 3,729 titles and abstracts and all 38 full-text reports against the eligibility criteria. Each reviewer's decisions were concealed from the other until comparison. Decisions were compared to establish the final selection; no discrepancies were identified, so discussion-based resolution was not required. All 38 reports selected for full-text assessment were retrieved, and 14 reports were included. The selection counts and full-text exclusion categories are presented in Figure 1.

For Ghisi and colleagues, the journal age range conflicts with its adult eligibility criteria, whereas the registry classifies all 45 participants as adults [12,16]. The original protocol permits outpatient or inpatient care, so an exclusively ambulatory setting is not established [13]. This report was retained in the final set, with these applicability uncertainties explicitly preserved rather than interpreted as resolved.

Data Charting and Verification

Asad Ashoor extracted study design, population and setting, sample denominators, anesthetic regimens, motor-scale versions and anchors, assessment intervals, timing origins, ambulation procedures and discharge criteria. Wesam Qurban checked all extracted information against the full texts; no corrections were required. Journal full texts were inspected for reports 1–9 and 11–13, while full reproductions in a linked thesis supplied reports 10 and 14 [14]. These reproductions were not counted as separate studies.

Furthermore, all 14 reports were examined for sensory regression, proprioception, balance, symptoms, sedation and circulatory readiness. Joint-position testing, movement detection, standing balance and positional blood-pressure measurements were distinguished from routine observations. Linked protocol procedures were distinguished from assessments confirmed in the publication. Missing descriptions were recorded as not identified in the inspected source, rather than evidence that a test was never performed. Appendices A and B present comparative extraction tables.

Methodological Assessment and Synthesis

Randomization and blinding were discussed during review; however, no standardized critical-appraisal tool was used, no structured study-level appraisal was recorded and no formal risk-of-bias ratings were assigned. Accordingly, study design descriptions should not be interpreted as quality ratings.

The synthesis was descriptive and grouped findings into motor-block recovery, readiness for mobilization, observed mobilization and discharge. No pooled effect estimates, anesthetic rankings or causal conclusions were produced. Aggregate participant numbers were not calculated because enrollment and outcome-specific analysis denominators differ. In addition, inconsistent definitions across publications and linked sources were retained and described rather than harmonized through assumptions.

Results

Study Selection

Of 3,729 records screened, 3,691 were excluded at title and abstract assessment. All 38 reports sought for full-text assessment were retrieved. Twenty-four were excluded: 14 did not assess motor

recovery or mobilization, six involved an inpatient or non-day-case surgical setting, and four used a technique other than single-shot spinal anesthesia. One primary reason was assigned to each excluded report. Consequently, 14 reports representing 14 studies were included.

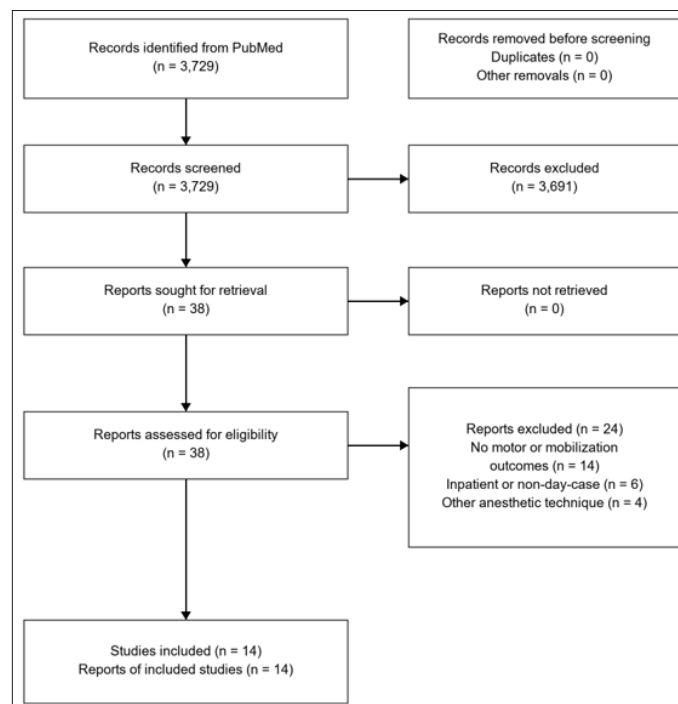


Figure 1: Study Selection Flow

The flow represents PubMed study identification only. Linked protocols, registries and thesis reproductions used to clarify included reports are supporting sources, not additional study-identification records.

Characteristics of the Included Reports

The 14 reports span 2006–2022. Eleven address knee arthroscopy; the other three address broader lower-limb procedures [16–18]. Thirteen describe randomized comparative designs; one combines sequential dose finding with a separate validation cohort [19]. The regimens encompass chlorprocaine, lidocaine, artiacaine, bupivacaine, prilocaine, mepivacaine and ropivacaine, with fentanyl or dexmedetomidine investigated in some reports. These findings describe the included set and do not establish the distribution of assessment practices across the entire literature.

To provide an overview, the evidence matrix below summarizes report-level characteristics. The inspected assessment methods are compared in Appendices A and B. All 14 have full-report sources, including two thesis reproductions. Source-specific ambiguities remain explicitly identified.

Ref	Report and sample	Surgical setting	Material inspected
1	Casati 2006 45 enrolled; 44 in recovery analysis after one consent withdrawal	Outpatient lower-limb surgery	Journal full text
2	Casati 2007 30 randomized	Outpatient knee arthroscopy	Journal full text
3	Dijkstra 2008 80 enrolled; 77 after three eligibility exclusions	Day-case lower-limb surgery	Journal full text
4	Forster 2011 80 randomized; 79 received assigned spinal; 78 perioperative analyses, 39 per arm	Day-case knee arthroscopy	Journal full text
5	Black 2011 50 enrolled as reported; actual drug allocations 23 prilocaine/26 bupivacaine; block analyses 22/26, with 20/26 at 1 h	Ambulatory knee arthroscopy	Journal full text
6	Ali Hassan 2015 50 randomized	Ambulatory knee arthroscopy, Saudi Arabia	Journal full text
7	Kahn 2015 56 enrolled and analyzed	Outpatient knee arthroscopy, USA	Journal full text
8	Teunkens 2016 99 randomized	Outpatient knee arthroscopy	Journal full text
9	Kumar 2018 90 randomized; one conversion to general anesthesia excluded	Day-care knee arthroscopy, India	Journal full text
10	Wesselink 2019 150 randomized	Ambulatory knee arthroscopy	Full report in thesis

11	Guntz 2021 80 randomized	Day-case knee arthroscopy, Belgium	Journal full text
12	Breebaart 2021 135 in study groups; 131 in regression table	Ambulatory knee arthroscopy, Belgium	Journal full text
13	Ghisi 2021 46 randomized; 45 treated and completed	Short lower-limb surgery; ambulatory-only setting not confirmed	Journal full text
14	Wesselink 2022 40 in dose-finding cohort; 50 in validation cohort	Outpatient knee arthroscopy at two hospitals	Full report in thesis

Motor Scales and Recovery Thresholds

First, the inspected reports do not use a single uniform operational definition of motor recovery. Several use Bromage scales coded from 0 to 3, but the wording of intermediate categories differs [20, 2, 5, 21]. Kumar and colleagues instead describe a modified scale from 1, indicating complete motor block, to 6, indicating no weakness [22]. A score should therefore be interpreted using the definition supplied by the individual study; numerical values alone cannot be combined across versions.

Furthermore, partial recovery and complete recovery serve different purposes. Breebaart and colleagues describe a Bromage score of 1 among the criteria for PACU transfer and a score of 0 for full motor recovery [5]. Guntz and colleagues identify complete recovery with Bromage 0 [11]. Ali Hassan's report refers to a return to 0–1 in its motor-duration description but also uses full motor recovery in transfer criteria; the two endpoint descriptions are not fully concordant [20].

Frequency of Assessment and Timing Origin

In addition to differences in scoring, assessment schedules varied within and between studies. Kahn and colleagues evaluated recovery at 15-minute intervals and timed outcomes from spinal injection [2]. Guntz and colleagues used early measurements at specified post-injection times followed by 10-minute PACU assessments [21]. Ghisi and colleagues changed from frequent early checks to 30-minute checks later in recovery [16]. Black and colleagues performed serial checks, including every 10 minutes in PACU, and then analyzed Bromage 0 versus residual block at one and two hours [23]. Accordingly, fixed-time analysis does not imply that observations occurred only at those two times.

Equally importantly, the starting point used to calculate recovery time requires attention. Kumar and colleagues define motor-block duration from its initial onset to complete recovery, whereas Wesselink's dose-finding report explicitly uses spinal injection as time zero [19,22]. Consequently, these intervals measure different quantities. The full reports establish end-of-injection timing for Casati 2006 and Förster 2011 [17, 24]. The exact motor timing origin is not explicit in Black's inspected methods [23]. Ghisi's linked protocol defines motor recovery, ambulation and discharge eligibility from spinal injection [11,12].

Relationship between Motor Recovery and Walking

With regard to walking, the clearest explicit sequence was found in Kahn's report: after sensory and motor resolution, walking was attempted every 15 minutes until successful [2]. Casati's full report separately measures motor recovery and ambulation, with crutches permitted in home-readiness criteria [1]. Moreover, Teunkens defines motor recovery as Bromage 0 and mobilization as a separate endpoint, although the walking procedure remains insufficiently specified for assuming unaided walking [3].

Moreover, Ali Hassan includes sitting tolerance before transfer and crutch-assisted walking, subject to surgical permission, among

home-discharge criteria [20]. Breebaart separately tabulates first ambulation and requires ambulation for hospital discharge [5]. Ghisi separately records unassisted ambulation and discusses possible contributions from staff availability, symptoms and readiness to walk [16]. Taken together, these distinctions show that walking time contains information beyond regression of the motor block.

Nonmotor Readiness Criteria

In addition to motor recovery, several inspected reports describe other recovery conditions. Ali Hassan requires a sensory level no higher than T12, stable vital signs and sitting tolerance before transfer to the ambulatory unit; vertigo, somnolence or a wish to lie down prevent that transfer [20]. Kahn assesses sensory recovery to S1 and begins walking attempts after both sensory and motor resolution [2]. Conversely, Guntz links complete sensory resolution to home eligibility without describing a separate timed walking test [21]. Thus, sensory recovery may be a prerequisite for walking in one report and a discharge endpoint in another.

Moreover, Breebaart records Ramsay sedation scores and vital signs every 15 minutes, with hemodynamic stability and pain control among PACU-transfer criteria. Home-discharge criteria additionally include ambulation, controlled pain, absence of nausea or vomiting and a low postvoid residual volume [5]. Ghisi's linked protocol defines a 20-point modified Aldrete score across ten domains, explaining the published discharge threshold of at least 18 [13, 16]. Its ambulation domain distinguishes standing and straight walking from upright vertigo and supine dizziness. The protocol permits a Romberg test as an alternative; however, the publication does not establish whether this alternative was used. Moreover, the total score does not identify the individual ambulation score. Kumar reports discharge scoring, although the inspected methods do not reproduce every score component [22].

Routine hemodynamic observations differ from an orthostatic challenge. No explicit supine-to-standing blood-pressure sequence was identified in the inspected main reports. Ghisi's protocol specifies five minutes of seated rest for vital-sign measurements, which does not establish an orthostatic protocol [13]. Casati 2006 separately reports toe-proprioception recovery, although the maneuver and recovery threshold are insufficiently specified [17]. Thus, the sources identify relevant assessment domains without supporting a uniform readiness test.

Furthermore, the full texts clarify the role of individual thresholds. Casati 2006 requires stable vital signs, oral intake, crutch walking, voiding and absence of nausea or pain for home eligibility [17]. Förster assesses bilateral sensory recovery to S2, but the L1 threshold on one limb applies to oral fluids, not permission to walk; actual home-discharge times were taken retrospectively from charts [24]. Black planned sensory follow-up to S2 but analyzed regression to L4 after observing patients walking and leaving before S2 recovery [23]. Thus, recovery thresholds must be attributed to the event they actually govern.

Participant denominators also differ by analysis. Casati enrolled 45 patients, with one consent withdrawal and 44 in the recovery figures [17]. Förster randomized 80, administered assigned spinal anesthesia to 79 and analyzed perioperative data for 78 [24]. Black describes 50 enrolled, but reports drug allocations of 23 and 26, and block-analysis denominators of 22 and 26; the one-hour motor analysis uses 20 and 26 [23]. These distinctions are preserved rather than replaced with a single sample count.

In addition, Casati 2007 assessed discharge both with and without a voiding requirement [1]. Dijkstra combined patient-recorded recovery times with investigator reassessment at 90 minutes [3]. Teunkens assessed cold-sensation recovery at S5 separately from first mobilization; some participants departed before complete sensory recovery [3]. In the two Wesselink reports, bladder assessment and spontaneous voiding contributed to discharge eligibility, while the later report additionally required controlled pain and absence of nausea or vomiting [4, 14,19]. These findings reinforce the distinction between sensory regression, functional activity and discharge.

Linked Source Definitions

The linked registration for Breebaart defines its motor-regression endpoint through active knee movement, whereas the publication also reports complete motor recovery [5, 11]. Consequently, the registered knee-movement endpoint and published complete recovery were charted separately. Linked sources were used to interpret the included reports; they did not expand the included-study set.

Discharge Endpoints

Finally, discharge outcomes distinguish PACU transfer, eligibility to leave hospital and actual departure [4, 7, 12]. Composite scores incorporate conditions beyond motor recovery. Although the Ghisi protocol clarifies the 20-point instrument, individual item scores are not reported [13, 16]. Consequently, a composite discharge threshold cannot be interpreted as a directly measured walking result. Differences between source definitions, observation schedules and outcome denominators were retained in the evidence map.

Discussion

Interpretation

Overall, this review identifies a practical distinction between return of movement, readiness to attempt activity, performance of activity and discharge. The retrieved methods demonstrate that these stages may be measured with different instruments and thresholds. Mapping those differences clarifies outcome interpretation without requiring a pooled comparison of anesthetic efficacy.

More specifically, scale coding is one source of potential misinterpretation. A value of 1 does not have a universal meaning across the Bromage variants in this set. Even when studies both describe complete recovery, their thresholds and testing procedures can differ. Retaining scale anchors and laterality therefore makes the comparison more interpretable than a scale name alone.

Beyond scale definitions, observation schedules also influence recorded recovery. When testing is intermittent, the true recovery event may occur between the last failed assessment and the first successful assessment. A study checking every 30 minutes can record recovery differently from one checking every 10 minutes even when underlying recovery is similar. This is a methodological interpretation of the measurement schedules, not an estimated bias

magnitude from these studies. Therefore, timing origins must also be preserved so that injection-to-recovery and onset-to-recovery measures remain distinguishable.

Relevance to Anesthesia and Rehabilitation

From an anesthesiology perspective, the central contribution is the measurement of recovery following a specified intrathecal regimen, including any sedation or adjuvants. In turn, the rehabilitation connection is the patient's ability and permission to undertake functional activity. Walking assistance, surgical restrictions, dizziness and staffing can affect the transition between these stages. Explicit transition criteria, such as those described by Kahn and Ali Hassan, offer useful extraction examples [2, 20]. Their predictive validity for safe mobilization is not established by this synthesis.

Nevertheless, the selected papers cannot establish which scale most accurately predicts safe walking. No dedicated validation study was identified within the included set; however, the search was limited to PubMed. Lack of a validation study here must not be interpreted as proof that none exists. Similarly, adverse-event reporting in these studies cannot establish a safe threshold for independent mobilization.

Implications for Assessment Research

These findings indicate that meaningful comparison depends on the instrument version, recovery threshold, tested limb, assessment interval and timing origin. In addition, the assistance provided, surgical restrictions and criteria for a walking attempt influence interpretation of a mobilization endpoint. Reporting these elements together would make the relationship between block regression and functional performance clearer.

Furthermore, potential questions for subsequent research include whether a motor scale predicts successful mobilization, whether a combined motor and functional assessment is reproducible, and how surgical restrictions and baseline mobility affect its interpretation. These are proposals arising from this evidence-mapping exercise, not demonstrated gaps across the entire field.

Proposed Reporting Framework for Future Studies

To improve comparability, we propose the following reporting elements for future spinal-anesthesia studies. These suggestions arise from the heterogeneity mapped in this review; they are not a validated reporting standard or a clinical clearance algorithm.

- **Define a Common Timing Origin:** For future studies, use the end of intrathecal local-anesthetic injection as the reference point for elapsed recovery times and report it explicitly. If block-onset duration, operating-room departure or another origin is also relevant, label that interval separately. Report observation intervals and the timing of the first successful assessment; existing study times should not be reinterpreted without source data.
- **Report Every Motor-Scale Anchor:** Name the scale version and reproduce each category's anatomical or movement definition, including intermediate scores, the tested limb and the complete-recovery threshold. A score of zero should be interpreted only within the specified scale.
- **Separate Movement from Functional Mobilization:** Report motor recovery, first standing, successful walking and discharge eligibility as distinct events. Specify the walking distance or other predefined task, assistance or walking aid, surgical weight-bearing restrictions, attempted assessments and the criterion for success. This review does not establish

a universal minimum walking distance.

- **Specify and Evaluate Safety Assessments:** Future trials should prospectively define and report any pre-mobilization assessment of positional blood pressure, heart rate, dizziness, sensory recovery and balance. Where orthostatic or balance testing is used, describe positions, rest periods, measurement times, instruments, thresholds and stopping rules. Record failed attempts, falls or near-falls when assessed. The value of a standardized assessment bundle should be tested; the included evidence does not establish mandatory tests or validated thresholds for unassisted walking.

Limitations

First, PubMed was the sole database used for study identification. Consequently, eligible reports indexed only in other databases or available through other sources may have been missed. No supplementary citation search contributed additional records. The included reports were published from 2006 to 2022 despite a final search in September 2026; their publication range must not be interpreted as demonstrating that no newer relevant research exists.

Second, eligibility criteria were refined during screening rather than specified in a prospective written protocol. Although earlier decisions were rechecked and the final selection underwent independent assessment by both reviewers, this approach increases the possibility of selection influenced by familiarity with the evidence. Concealing reviewers' decisions until comparison does not remove prior familiarity with the reports. No protocol was registered.

Third, randomization and blinding were discussed without a structured appraisal or recorded study-level ratings. Therefore, the review cannot establish confidence in comparative effects or justify clinical treatment recommendations. The evidence is concentrated in knee arthroscopy, and applicability to frail patients or other surgical populations remains uncertain. The inclusion of Ghisi's report requires additional caution because its adult age reporting and exclusively ambulatory setting are not fully resolved [12,13, 16].

Finally, scale anchors, walking assistance, outcome-specific timing origins and denominators were incompletely or inconsistently reported in some sources. For example, the intermediate categories of Kumar's 1-to-6 motor scale could not be established from the inspected methods [22]. Protocol-specified balance assessments do not demonstrate that those assessments were performed. These uncertainties limit comparability, and absence of reporting must not be interpreted as absence of clinical assessment.

Conclusion

Across 14 included studies, assessment after spinal anesthesia varied in motor-scale coding, recovery thresholds, observation schedules, timing origins and mobilization procedures. Moreover, sensory recovery, symptoms and discharge requirements contributed information beyond return of movement. Accordingly, motor recovery, readiness to attempt mobilization, successful walking and discharge should be reported as separate outcomes. Future assessment studies should specify these definitions and evaluate their relationship to functional recovery. The present findings are limited by a single-database search, evolving eligibility criteria and the absence of structured critical appraisal.

Declarations

Author Contributions: Asad Ashoor performed the initial screening and data extraction and prepared the first manuscript

draft. Wesam Qurban verified the initial screening decisions and extracted data and reviewed and revised the manuscript. Both authors subsequently completed independent screening and full-text eligibility assessment, with decisions concealed until comparison.

Ethics Approval and Consent to Participate: This review used published reports and publicly available secondary sources. No participants were recruited, no interventions were performed, and no identifiable individual-level data were collected. Ethics approval and individual patient consent were therefore not sought for this literature review.

Funding: This review received no funding.

Conflicts of Interest: The authors declare no conflicts of interest.

Data Availability: The search strategy and study-level extraction tables are provided in this manuscript and its appendices. The study-selection totals are reported in Figure 1.

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