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Review

Prehabilitation for patients undergoing pelvic exenteration

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ABSTRACT

Background: Pelvic exenteration (PE) is a highly complex surgical procedure associated with significant morbidity and prolonged recovery. Although prehabilitation has been shown to improve perioperative outcomes in colorectal and other major oncologic surgeries, its role in PE remains unclear. This study aims to evaluate the potential application and clinical relevance of prehabilitation for patients undergoing PE.

Methods: A narrative review of the literature was conducted to examine the role of prehabilitation in major oncologic surgery, with a focus on its applicability to pelvic exenteration. Relevant studies were identified through searches of PubMed, Embase, and Google Scholar. Evidence from colorectal and other surgical populations was included when direct PE-specific data were lacking.

Results: Prehabilitation programs, typically incorporating exercise, nutritional optimization, and psychological support, have been shown to improve functional capacity, reduce postoperative complications, and shorten hospital stays in colorectal surgery. However, no studies were identified that specifically evaluate prehabilitation in the PE population. Patients undergoing PE often present with significant physiological and psychological burdens, suggesting a potentially greater benefit from prehabilitation. Key challenges include treatment-related toxicity, nutritional deficits, and the complexity of coordinating multimodal interventions within constrained preoperative timelines.

Conclusions: The physiological rationale and supporting data from related surgical populations suggest that prehabilitation would confer meaningful benefits for patients undergoing pelvic exenteration. Prospective studies are needed to assess the "best" type of exercise and rehabilitation programs prior to PE.

1. Introduction

Colorectal cancer (CRC) is the third most common malignancy and the second leading cause of cancer-related death worldwide [1]. Rectal cancer accounts for approximately one-third of CRC cases, with a proportion presenting as locally advanced disease involving adjacent pelvic structures [2]. In these patients, conventional total mesorectal excision (TME) is insufficient, and more radical surgery is required.

Pelvic exenteration (PE), the *en bloc* removal of some or all pelvic viscera, is among the most technically demanding operations in the abdominal surgical armamentarium [3]. It is performed in specialized centres for locally advanced or recurrent rectal cancer and selected other

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pelvic malignancies. Contemporary series report overall perioperative morbidity rates of 50–70%, mortality of 1–5%, and reconstructive complexity that frequently includes myocutaneous flap harvest, urinary diversion, and vascular or sacral resection [4,5]. Many patients undergoing pelvic exenteration will have received neoadjuvant chemoradiotherapy (nCRT), which contributes to deconditioning, treatment toxicity, and increased physiological vulnerability [6,7].

Prehabilitation, the proactive optimization of a patient's functional capacity in the preoperative period, has attracted growing interest as a strategy to improve perioperative outcomes in major surgery. It enhances physiological reserve and supports recovery from surgical stress [8]. Evidence from randomized controlled trials (RCTs) and systematic reviews demonstrates clinically meaningful reductions in postoperative complications and hospital length of stay (LOS), as well as accelerated functional recovery, following prehabilitation in colorectal and major upper abdominal surgery [9–12]. Prehabilitation is increasingly recognized as a complementary adjunct to Enhanced Recovery After Surgery (ERAS) protocols, emphasizing multimodal optimization of the surgical patient across the preoperative, intraoperative, and postoperative continuum [13–15].

Despite this growing body of evidence, direct evidence for prehabilitation in the pelvic exenteration population remains limited. This narrative review critically synthesizes the available indirect evidence and argues that developing a PE-specific prehabilitation framework is an unmet research priority in pelvic oncological surgery.

2. Methods

A narrative review was conducted to examine the evidence supporting prehabilitation in patients undergoing pelvic exenteration and to evaluate the applicability of data from related major oncological surgical populations. Searches were performed in PubMed, Embase, and Google Scholar for articles published up to April 2025.

Search terms were structured using Boolean operators to combine key concepts relating to prehabilitation, pelvic exenteration, and perioperative optimization. The core search strategy included combinations of: ("prehabilitation" OR "pre-operative optimization" OR "preoperative conditioning") AND ("pelvic exenteration" OR "exenterative surgery" OR "locally advanced rectal cancer" OR "colorectal surgery") AND ("enhanced recovery" OR "ERAS" OR "perioperative care") AND ("exercise" OR "aerobic training" OR "resistance training" OR "cardiopulmonary exercise testing" OR "CPET") AND ("nutrition" OR "malnutrition" OR "sarcopenia") AND ("frailty" OR "functional capacity") AND ("psychological support" OR "quality of life"). Terms were adapted for each database, with appropriate use of MeSH and Emtree headings to maximise sensitivity.

Studies were selected based on relevance to prehabilitation interventions, perioperative outcomes, and applicability to complex pelvic surgery, with priority given to systematic reviews, randomised controlled trials, and high-quality cohort studies. Given the limited direct evidence in pelvic exenteration, data from colorectal and other major oncological surgical populations were included where clinically relevant. Findings were synthesized qualitatively.

3. What is prehabilitation?

Prehabilitation is a preoperative, multimodal strategy designed to enhance physiological and psychological resilience before surgery [8,16]. Unlike postoperative rehabilitation, it focuses on improving functional capacity in advance, thereby increasing the reserve available to withstand surgical stress. It typically comprises three components: exercise, nutrition, and psychological support.

3.1. Exercise

Exercise is the core component, including tailored aerobic and resistance training. Aerobic training is prescribed using cardiopulmonary exercise testing (CPET)-derived parameters, primarily peak oxygen uptake (VO_2 peak) and the ventilatory anaerobic threshold, to quantify baseline cardiorespiratory fitness and calibrate training intensity to the individual [17]. CPET is well established as a validated preoperative risk stratification tool, and VO_2 peak at the anaerobic threshold serves as an independent predictor of perioperative mortality and major morbidity in major abdominal surgeries [18–20]. Resistance training targets sarcopenic muscle loss, which is prevalent in oncological populations and associated with increased postoperative complications, prolonged LOS, and inferior disease-specific outcomes [21,22]. The combination of aerobic and resistance modalities is considered superior to either alone and is used in the most methodologically rigorous trials [9,23,24].

3.2. Nutrition

Nutritional optimization targets the high prevalence of malnutrition among surgical oncology patients, which is linked to complications, impaired wound healing, and longer hospital stays [25]. Systematic nutritional screening, such as the Nutritional Risk Screening 2002 (NRS-2002), is the recommended first step, followed by targeted dietary optimization that incorporates protein supplementation (typically 1.2–1.5 g/kg/day or higher), caloric augmentation, and, in appropriate surgical contexts, perioperative immunonutrition [26]. European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines support integrating nutritional assessment into the perioperative pathway as a standard of care [26].

3.3. Psychological optimization

Psychological support addresses preoperative anxiety and related factors that may adversely affect recovery [27]. Structured psychological support, including cognitive behavioural therapy (CBT), mindfulness-based stress reduction, and patient education, is integrated into multimodal prehabilitation programs to address these modifiable risk factors and improve surgical self-efficacy [9,16].

3.4. Physiological rationale

Preoperative functional capacity is a key determinant of postoperative outcomes. A VO_2 peak below 11 mL/kg/min at the anaerobic threshold or below 15 mL/kg/min at peak effort identifies patients at substantially elevated perioperative risk, though operative-context-specific thresholds vary [18,19]. Sarcopenia, defined by the revised European Working Group on Sarcopenia in Older People (EWGSOP2) criteria [21], is associated with major complications (RR 1.40, 95% CI 1.20–1.64) and inferior disease-specific outcomes in gastrointestinal oncologic surgery [22]. Aerobic training has been shown to increase VO_2 peak, attenuate deconditioning, and expand cardiorespiratory reserve within a clinically relevant preoperative interval [28–30]. Nutritional and resistance training interventions that mitigate sarcopenic change are therefore both biologically justified and clinically motivated [16,31]. Prehabilitation aims to improve these modifiable factors through exercise and nutritional support, thereby enhancing physiological reserve before surgery.

4. Evidence for prehabilitation in major abdominal surgery

The evidence base for prehabilitation in colorectal and major abdominal surgery has evolved over the past two decades. Carli et al. conducted one of the earliest RCTs of structured prehabilitation in colorectal surgery, demonstrating that a four-week supervised exercise program before colorectal resection significantly improved functional walking capacity and reduced postoperative fatigue compared with standard care [23]. Building on this, Gillis et al. randomized 77 patients undergoing colorectal resection for cancer to trimodal prehabilitation

Table 1
Summary of key prehabilitation studies in colorectal and major abdominal surgery.

Study	Population	Intervention	Comparator/Outcomes	Key Findings
Carli et al. (Br J Surg, 2010) [23]	n = 112; elective colorectal surgery	4-week supervised exercise prehabilitation	Standard care; 6MWT; postoperative fatigue	Improved preoperative walking capacity and reduced postoperative fatigue in prehabilitation arm
Gillis et al. (Anesthesiology, 2014) [9]	n = 77; colorectal cancer resection	Trimodal prehabilitation: aerobic exercise, protein supplementation, anxiety reduction	Equivalent postoperative rehabilitation programme; 6MWT at 8 weeks	Greater functional recovery at 8 weeks; greatest benefit in patients achieving ≥20m preoperative improvement in 6MWT
Barberan-Garcia et al. (Ann Surg, 2018) [34]	n = 144; high cardiac risk, major elective abdominal surgery	Personalized HIIT prehabilitation (≥6 supervised sessions over 4 weeks)	Standard care; Clavien-Dindo ≥ II complications	Significant reduction in complications (31% vs 62%; p = 0.009); meaningful improvement in VO_2peak
Minnella et al. (JAMA Surg, 2018) [24]	n = 51; oesophagogastric cancer surgery	Trimodal prehabilitation (exercise, nutrition, psychological) for 8 weeks	Standard care; VO_2peak; 6MWT; postoperative complications	Improved functional capacity at time of surgery; superior postoperative outcomes compared with control
Molenaar et al. PREHAB RCT (Ann Surg, 2023) [33]	n = 251; elective colorectal cancer surgery; multicentre	4-week trimodal prehabilitation (supervised exercise, nutritional counselling, anxiety reduction)	Standard care; 30-day complication rate; functional recovery at 8 weeks	Significant reduction in postoperative complications; enhanced functional recovery particularly in frail patients
Moran et al. (Surgery, 2016) [10]	21 studies; intra-abdominal surgery; systematic review and meta-analysis	Exercise prehabilitation (various modalities)	Standard care; complications; LOS	Significant reduction in complications (OR 0.52, 95% CI 0.31–0.89) and hospital LOS
Hughes et al. (World J Surg, 2019) [11]	Multiple RCTs and cohort studies; major abdominal surgery; meta-analysis	Multimodal prehabilitation	Standard care; complications; LOS; QoL	Pooled reductions in complication rates and LOS; heterogeneity noted across intervention modalities
West et al. (Br J Anaesth, 2015) [28]	n = 39; locally advanced rectal cancer undergoing nCRT; pilot RCT	Structured exercise programme during neoadjuvant chemoradiotherapy	Control (no structured exercise); VO_2peak; 6MWT	Attenuation of nCRT-related VO_2peak decline; programme feasible and safe during cytotoxic treatment

6MWT, 6-min walk test; HIIT, high-intensity interval training; LOS, length of stay; nCRT, neoadjuvant chemoradiotherapy; OR, odds ratio; QoL, quality of life; RCT, randomised controlled trial; VO_2peak, peak oxygen uptake.

incorporating aerobic exercise, protein supplementation, and CBT-based anxiety reduction, or to an equivalent postoperative rehabilitation program [9]. Patients in the prehabilitation group showed superior recovery of functional walking capacity at eight weeks, with a significantly higher proportion recovering to or above baseline exercise capacity than the rehabilitation group (84 vs. 62%), and a greater proportion achieving a clinically meaningful improvement in the 6-min walk test (≥20 m) during the preoperative period (53 vs. 15%). Subsequent work by Minnella et al. demonstrated, in a five-year observational cohort, that multimodal prehabilitation consistently improved functional capacity before and after colorectal cancer surgery, with benefits maintained across a wide range of age groups and baseline fitness levels [32].

The PREHAB multicenter RCT provides the strongest evidence to date, demonstrating reduced 30-day postoperative complications and improved functional recovery after four weeks of trimodal prehabilitation before colorectal cancer surgery [33]. The trial showed a significant reduction in overall 30-day postoperative complications and a higher proportion of patients recovering functional capacity at eight weeks postoperatively, with the magnitude of benefit most pronounced among patients with higher preoperative frailty burden.

Beyond colorectal surgery, Barberan-Garcia et al. conducted a blinded RCT of personalized, high-intensity interval training (HIIT)-based prehabilitation in patients at elevated cardiac risk undergoing major elective abdominal surgery, demonstrating a significant reduction in postoperative complications (Clavien-Dindo grade ≥ II) compared with control (31% vs. 62%; p = 0.009), along with a meaningful improvement in VO_2peak [34]. Minnella et al. reported comparable findings in oesophagogastric cancer surgery, where trimodal prehabilitation produced superior functional capacity both at the time of surgery and in the postoperative period compared with usual care [24]. Dronkers et al. reported that a structured preoperative therapeutic program was feasible and safe, and was associated with preserved functional capacity at the time of surgery in elderly patients undergoing elective abdominal oncological procedures [35].

These individual trial findings are reinforced by systematic reviews and meta-analyses. Moran et al. reviewed 21 prehabilitation studies before intra-abdominal surgery, demonstrating significant reductions in postoperative complications (OR 0.52, 95% CI 0.31–0.89) and hospital LOS [10]. Hughes et al. confirmed pooled reductions in complication rates and LOS in a meta-analysis of prehabilitation before major abdominal surgery, with heterogeneity attributable to variation in intervention components and delivery modality [11]. Gillis et al. demonstrated, in a systematic review of nutritional prehabilitation in colorectal surgery, that protein and caloric supplementation independently contribute to recovery of functional capacity, with effects additive to those of structured exercise [36]. Santa Mina et al. reported that total-body prehabilitation was associated with improved postoperative physical function, with the greatest benefit observed in patients with the lowest baseline fitness [37]. Thomas et al. synthesized RCT evidence for prehabilitation before major intra-abdominal cancer surgery, noting consistent benefit signals across exercise, nutritional, and psychological domains, while acknowledging limitations inherent to blinding methodology, heterogeneous outcome measurement, and variable follow-up duration [12].

This evidence supports the integration of prehabilitation into perioperative care pathways. ERAS guidelines emphasize preoperative optimization, including functional, nutritional, and psychological preparation [13,14]. Additionally, systematic reviews of prehabilitation in abdominal cancer surgery, including the analysis by Hijazi et al. [15], further corroborate these findings across operative subtypes. Key trials are summarized in Table 1.

5. WHY pelvic exenteration is different

Evidence from colorectal surgery cannot be directly extrapolated to pelvic exenteration (PE), as this population has distinct physiological, nutritional, and psychological challenges.

5.1. *Operative magnitude and physiological demand*

PE involves resection and reconstruction of multiple pelvic organ systems, commonly requiring 6–12 h of operative time, with blood loss frequently exceeding 1 L, and, in extended resections, may include myocutaneous flap harvest, urinary diversion formation, iliac vessel resection, or partial sacrectomy [3,4]. The reconstructive burden is

Table 2
Proposed multimodal prehabilitation protocol for patients undergoing pelvic exenteration.

Component	Intervention	Rationale	Evidence Source
Exercise – Aerobic	CPET-guided moderate-to-high intensity aerobic training (3× per week, 30–45 min sessions; cycle ergometry or structured walking); adapted for haematological tolerance during nCRT	Augments VO_2peak; attenuates nCRT-induced deconditioning; expands cardiorespiratory reserve before a high-demand surgical insult	Older et al. [18]; West et al. [28]; Barberan-Garcia et al. [34]; Loughney et al. [52]
Exercise – Resistance	Supervised progressive resistance training (2× per week; major muscle groups; RPE 13–15); modified intensity during periods of nCRT toxicity	Attenuates sarcopenic muscle loss; preserves functional independence; facilitates early postoperative mobilisation	Cruz-Jentoft et al. [21]; Simonsen et al. [22]; Minnella et al. [32]
Nutrition – Screening & Assessment	NRS-2002 or MUST at diagnosis; 4-weekly reassessment; CT-derived skeletal muscle index; specialist oncology dietitian review at each assessment	Identifies pre-existing malnutrition and cachexia; guides individualized nutritional prescription; monitors sarcopenic change across treatment pathway	Kondrup et al. [25]; Weimann et al. [26]; Arends et al. [47]
Nutrition – Supplementation	Protein supplementation (1.0–1.5 g/kg/day); caloric optimization to achieve energy balance; oral immunonutrition (arginine, omega-3 fatty acids, nucleotides) for 5–7 days preoperatively	Corrects protein-energy malnutrition; immunonutrition reduces postoperative infectious complications and LOS; protein supplementation supports muscle mass preservation	Weimann et al. [26]; Gillis et al. [36]; Arends et al. [47]
Psychological Preparation	CBT-based anxiety reduction; stoma and urinary diversion education with stomal therapy nursing; psychosexual counselling; facilitated peer-support programme from prior PE patients; mindfulness-based stress reduction	Reduces preoperative anxiety and depression; improves illness perception and surgical self-efficacy; psychoneuroimmunological evidence supports direct benefit to immune function and wound healing	Kiecolt-Glaser et al. [27]; Gillis et al. [9]; Silver & Baima [8]
Monitoring & Evaluation	Serial CPET at baseline, pre-surgical, and 3 months postoperatively; 6MWT at same time points; validated PRO measures (EORTC QLQ-C30, QLQ-CR38, and a bladder/urinary module such as QLQ-BLM30); safety monitoring for nCRT-related toxicity; adherence and adverse event documentation	Enables adaptive dose-adjustment; captures full functional trajectory across treatment episode; generates trial-quality outcome data; ensures patient safety throughout prehabilitation; no single validated instrument currently captures all relevant QoL domains following PE a multi-instrument battery is recommended pending development of a PE-specific PRO tool	Dindo et al. [39]; Thomas et al. [12]; Molenaar et al. [33]; Westin et al. [51]

CBT, cognitive behavioural therapy; CPET, cardiopulmonary exercise testing; CT, computed tomography; EORTC QLQ-BLM30, European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Bladder Cancer Module 30; EORTC QLQ-C30, European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30; EORTC QLQ-CR38, European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Colorectal Cancer Module 38; LOS, length of stay; MUST, Malnutrition Universal Screening Tool; nCRT, neoadjuvant chemoradiotherapy; NRS-2002, Nutritional Risk Screening 2002; PE, pelvic exenteration; PRO, patient-reported outcome; RPE, rating of perceived exertion; VO_2peak, peak oxygen uptake.

substantial, and the resulting physiological insult substantially exceeds that of standard colonic or rectal resection. The associated physiological stress is greater, and conventional CPET risk thresholds may not fully capture perioperative risk in this population [18,38]. The Clavien-Dindo classification provides the most internationally standardized framework for complications [39].

5.2. Neoadjuvant chemoradiotherapy

The majority of PE candidates will have received long-course pelvic nCRT, typically 45–54 Gy with concurrent fluoropyrimidine-based chemotherapy [6,40,41]. However, long-course nCRT induces progressive skeletal muscle loss, adipose tissue fibrosis, hematologic suppression, and impaired gastrointestinal function, all of which contribute to declining physical performance status by the time of surgical assessment [42–45]. In a blinded interventional pilot study of patients with locally advanced rectal cancer, West et al. demonstrated that structured exercise during nCRT attenuated the decline in VO_2 peak compared with controls, with patients in the control arm falling below accepted perioperative risk thresholds by treatment completion [28]. This finding has direct implications for the timing of prehabilitation in this population: the pre-treatment window before nCRT-related deconditioning supervention may be the most physiologically impactful interval for functional optimization.

5.3. Malnutrition and cancer cachexia

Patients with locally advanced pelvic malignancies bear a disproportionate burden of preoperative malnutrition, driven by tumour-related anorexia, obstructive symptoms, and the catabolic effects of both neoplastic disease and cytotoxic therapy [25,46]. ESPEN guidelines and cancer-specific nutritional guidelines advocate systematic screening and early nutritional intervention for surgical oncology patients [25,26,47]. However, the complexity of nutritional pathology in the PE population may exceed what standard nutritional prehabilitation protocols are equipped to address.

5.4. Frailty

Frailty, defined by instruments such as the Fried Frailty Phenotype [48] or the Rockwood Frailty Index [49], is an increasingly recognized predictor of adverse outcomes after major abdominal surgery. Its prevalence is likely higher in PE patients because of the additive burdens of advanced malignancy, prior cytotoxic treatment, nutritional depletion, and comorbidity. Importantly, frailty impairs adaptive neuroendocrine, musculoskeletal, and immunological responses to exercise training and may limit responsiveness to prehabilitation interventions [33,50].

5.5. Psychological burden

PE results in major, often permanent changes in bodily function, including stomas, urinary diversion, and sexual dysfunction. These changes contribute to significant psychological distress, which may negatively affect recovery [27,51]. The role of structured psychological support in this setting remains underexplored.

Overall, patients undergoing PE differ substantially from those in standard prehabilitation trials, limiting the direct extrapolation of existing evidence.

6. Potential role of prehabilitation in pelvic exenteration

Despite the absence of direct evidence, the theoretical case for prehabilitation in PE is compelling, and biological plausibility is strongly supported by available mechanistic and indirect data.

The treatment pathway for locally advanced rectal cancer, from diagnostic staging, typically spans 16–24 weeks. This preoperative interval represents a substantial and exploitable opportunity for systematic multimodal prehabilitation [16,31]. Initiating prehabilitation at

diagnosis and adapting the program iteratively through the neoadjuvant period could mitigate treatment-related deconditioning and optimize patients before surgery [28]. Evidence that structured exercise during nCRT is feasible, safe, and associated with attenuated fitness decline provides further mechanistic justification for this approach [52].

Targeting an increase in VO $_2$ peak of 1–2 mL/kg/min within an 8–12- week program [29,30] would be expected to reduce complication rates [34]. For a procedure with a baseline morbidity of 50–70%, a modest absolute risk reduction would translate into meaningful benefit at the population level. Incorporating resistance training is an important component for a population at high risk of sarcopenic progression [52].

Nutritional prehabilitation requires a more individualized approach than simple caloric supplementation. Serial nutritional screening using NRS- 2002 or MUST, serial body composition assessment including CT-derived skeletal muscle index [21,22], and protein-targeted supplementation (1. 5–2. 0 g/kg/day) should form the nutritional framework [25,26]. Perioperative oral immunonutrition, incorporating arginine, omega- 3 fatty acids, and nucleotides, has demonstrated meaningful reductions in infectious complications and LOS in colorectal surgery [26,36] and warrants prospective evaluation in the PE context.

The psychological domain merits structured attention in this population, encompassing stoma and urinary diversion education, psychosexual counselling, anxiety management, and facilitated peer support, which has the potential to improve coping and perioperative outcomes [27,53].

A multimodal prehabilitation program encompassing all three domains, delivered by a dedicated perioperative multidisciplinary team, is likely to be effective. Programs should be adaptable during neoadjuvant therapy to account for treatment-related toxicity and fatigue. A proposed framework is outlined in Table 2.

7. Conclusion

Pelvic exenteration is a highly complex operation performed on a high-risk patient population due to the significant physiological and psychological burden. Prehabilitation offers a pragmatic strategy to improve outcomes by targeting modifiable risk factors before surgery, as evidenced by other major surgical procedures.

CRediT authorship contribution statement

Omar Abu Saadeh: Conceptualization, Investigation, Methodology, Writing – original draft. **Hugo C. Temperley:** Conceptualization, Investigation, Methodology, Writing – original draft. **Benjamin M. Mac Curtain:** Conceptualization, Formal analysis, Investigation, Writing – original draft. **Padraig Cronin:** Investigation, Writing – review & editing. **Niall J. O'Sullivan:** Investigation, Writing – review & editing. **Peter E. Lonergan:** Resources, Writing – review & editing. **Christina E. Buckley:** Resources, Writing – review & editing. **Eamon Francis:** Resources, Writing – review & editing. **Louise McLoughlin:** Resources, Writing – review & editing. **Ben Creavin:** Supervision, Writing – review & editing. **Michael E. Kelly:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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