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Effect of Virtual Reality-Based Yoga on Shoulder Strength in the Geriatric Population: A Prospective Interventional Study

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Abstract

Background

Age-related reduction in muscle strength affects upper-limb function and independence in older adults. Virtual reality (VR) may provide an engaging way to deliver exercise, but evidence for VR-based yoga to improve shoulder strength in older adults remains limited.

Objective

The primary objective of this study was to compare the effects of VR-based yoga and conventional physiotherapy exercises on shoulder muscle strength in older adults aged 60-75 years following coronary artery bypass grafting (CABG) surgery. The secondary objective was to evaluate and compare changes in upper-limb function using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Methods

A prospective intervention study was conducted among 40 geriatric individuals having reduced shoulder muscle strength. This manuscript describes a planned two-arm, parallel-group, assessor-blinded, prospective intervention study. Forty participants were allocated in a 1:1 ratio to VR-based yoga (n = 20) vs. conventional shoulder exercise (n = 20). The planned intervention is three sessions per week for six weeks, subject to confirmation of the final protocol. Shoulder strength will be measured using hand-held dynamometry, and upper-limb function using the DASH questionnaire at baseline and Week 6. The primary analysis compared between-group change with baseline-adjusted analysis considered where appropriate.

Discussion

The study is intended to examine whether VR-based yoga is a feasible and effective exercise-delivery approach for shoulder strengthening in older adults. Findings were reported after recruitment, intervention delivery, and analysis were completed.

Categories: Therapeutics, Geriatrics
Keywords: geriatric rehabilitation, older adults, shoulder strength, study protocol, virtual reality, yoga

Introduction

Ageing is accompanied by progressive changes in skeletal muscle mass and strength, which may contribute to functional limitations and disability. Reduced muscle strength is a key feature of contemporary definitions of sarcopenia [1,2]. Although lower-limb weakness is frequently emphasized in geriatric rehabilitation, upper-limb strength is also important for daily activities, such as reaching, lifting, dressing, grooming, and bathing. Shoulder disorders are common among older adults and may compromise functional independence [3]. Progressive resistance exercise is an established approach for improving muscle strength in older adults, and evidence indicates that the training dose may influence outcomes [4]. Yoga combines physical postures, breathing exercises, and relaxation and may support flexibility, balance, and mobility in people aged 60 years and older [5]. Reviews have also examined the potential effects of yoga on cognition and mental health in older adults [6]. Some yoga postures require sustained activation of the shoulder girdle; however, the specific effects of delivering yoga through a virtual reality (VR) platform on shoulder muscle strength require further evaluation. Exercise participation and adherence may be influenced by motivation, accessibility, and confidence. Exercise games and VR-based interventions can provide interactive tasks and feedback. Reviews have described the use of exergames in older adults and have considered their feasibility, safety, and effectiveness [7]. VR has also been investigated in rehabilitation settings, including neurological rehabilitation [8,9]. These findings provide a rationale for evaluating VR as a method of exercise delivery, but they do not establish whether VR-based yoga is more effective than conventional shoulder exercise. Regular physical activity is an important component of healthy ageing because it helps maintain functional capacity and may reduce physical decline. The World Health Organization recommends that older adults

undertake muscle-strengthening activities involving major muscle groups on at least two days per week. Exercise programmes should be adapted to individual functional capacity and progressed according to tolerance [10]. These recommendations emphasize the importance of structured exercise interventions for maintaining strength and physical independence in older populations. Evidence also suggests that yoga may have beneficial effects on physical function in older adults. A systematic review and meta-analysis by Ko et al. reported effects of yoga on muscle strength, balance, and flexibility among community-dwelling older adults [11]. However, differences in study designs and intervention characteristics mean that these findings should be interpreted cautiously. Although this evidence supports yoga as a potential exercise option for older adults, its effects on shoulder-specific muscle strength remain an area for investigation. VR-based exercise has received increasing attention as a way of delivering interactive rehabilitation programmes. Visual environments, task-orientated activities, and performance feedback may offer an alternative to conventional exercise delivery. Doré et al. examined the acceptability, feasibility, and effectiveness of immersive virtual technologies for promoting exercise in older adults [12]. Vasodi et al. also reported potential effects of VR-based exercise on selected quality-of-life, balance, and psychological outcomes in older populations [13]. Improvements in these outcomes, however, cannot be interpreted directly as evidence of increased shoulder muscle strength. A systematic review and meta-analysis by Lee et al. found that immersive VR training could improve selected balance outcomes in older adults, although benefits were not consistent across gait and mobility measures [14]. The authors also identified the need for further research on adherence, usability, feasibility, and adverse effects. These findings indicate that the effects of VR interventions may depend on the outcomes assessed, programme characteristics, and participant population. Evidence supporting VR for balance and mobility should therefore not be assumed to establish its effectiveness for shoulder strengthening. The existing evidence highlights the potential benefits of yoga and VR-based exercise in improving selected physical and functional outcomes among older adults. However, limited evidence is available regarding the effectiveness of VR-based yoga specifically for improving shoulder muscle strength and upper-limb function. Furthermore, direct comparisons between VR-based yoga and conventional physiotherapy shoulder exercises in older adults with reduced shoulder muscle strength remain limited. The present study aimed to compare the effectiveness of VR-based yoga with conventional physiotherapy exercises in improving shoulder muscle strength and upper-limb function among older adults aged 60-75 years following coronary artery bypass grafting (CABG) surgery. Shoulder muscle strength was considered the primary outcome, while upper-limb function, assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, was considered the secondary outcome. The study hypothesized that VR-based yoga would demonstrate greater improvements in shoulder muscle strength and upper-limb function compared with conventional physiotherapy exercises. The primary objective of this study was to evaluate the effect of VR-based yoga compared with conventional physiotherapy exercises on shoulder muscle strength in older adults aged 60-75 years following CABG surgery. The secondary objective was to assess changes in upper-limb function using the DASH questionnaire. We hypothesized that VR-based yoga would result in greater improvements in shoulder muscle strength and upper-limb function compared with conventional physiotherapy exercises.

Materials And Methods

Study design and reporting

This study was conducted as a two-arm, parallel-group, assessor-blinded, prospective intervention study involving 40 participants. Participants were allocated to either the VR-based yoga group or the conventional shoulder exercise group in a 1:1 ratio, with 20 participants in each group. The outcome assessor who measured shoulder muscle strength and collected DASH scores was blinded to group allocation. Participants and treating physiotherapists could not be blinded because the interventions differed [15].

Setting

The study was conducted at Krishna College of Physiotherapy, Karad, Maharashtra, India. Assessments and treatment were carried out in the outpatient physiotherapy department from 3 September 2026 to 14 October 2026.

Participants

The study included 40 adults aged 60-75 years, of either sex, who met the eligibility criteria and provided informed consent.

Inclusion criteria

Participants were eligible for inclusion if they were aged 60-75 years and older adults who were at least two months post-CABG surgery at the time of enrolment, demonstrated reduced shoulder muscle strength as defined before recruitment, were medically stable to participate in the physiotherapy intervention, could sit or stand independently, and were able to understand and follow simple instructions.

Exclusion criteria

The exclusion criteria were shoulder fracture, dislocation, or shoulder surgery within the previous six

months; a known full-thickness rotator cuff tear or severe shoulder pain (visual analogue scale score: >7/10); uncontrolled hypertension, unstable cardiac disease, or severe visual, vestibular, or balance disorders that could make participation unsafe; a history of seizures or marked susceptibility to motion sickness where relevant to the VR equipment; and regular yoga practice or structured shoulder-strengthening training during the previous three months.

Sample size

The study included 40 participants, with 20 participants allocated to each group using a 1:1 allocation ratio. The sample size was determined based on the availability of eligible participants during the study period and the feasibility of conducting the intervention within the available institutional setting. Although this sample provided preliminary information regarding the outcomes of VR-based yoga and conventional physiotherapy, it may have limited statistical power to detect smaller between-group differences. Under a simple independent-groups comparison, a sample of 20 participants per group would be expected to detect approximately a large standardized between-group effect (Cohen's d ≈ 0.9) with 80% power at a two-sided significance level of 0.05 [16,17]. This estimate represents the approximate detectable effect for the achieved sample size rather than an a priori sample size calculation. Therefore, the findings should be interpreted cautiously, and future studies with larger samples and formal sample size calculations based on clinically meaningful effect sizes are recommended.

Recruitment and blinding

Participants were recruited from the geriatric physiotherapy outpatient department. After baseline assessment, participants were allocated to the two groups in a 1:1 ratio using a computer-generated random sequence. Allocation concealment was performed using sequentially numbered, opaque, sealed envelopes prepared and opened by a person who was not involved in outcome assessment. The outcome assessor was blinded to group allocation. Participants and treating physiotherapists were not blinded because of the nature of the interventions.

Interventions

Both groups received supervised exercise sessions over six weeks. The manuscript specifies 45-minute sessions, three days per week, for a planned total of 18 sessions. Each session included a warm-up, a main exercise component, and a cool-down. A physiotherapist supervised the sessions. Blood pressure and heart rate were monitored before and after sessions where clinically appropriate, perceived exertion was recorded using the Borg scale [16], and adverse events were documented.

VR-based yoga group

Participants in the experimental group received a VR-based yoga intervention using the Meta Quest 3 headset. The VR intervention was delivered through the Meta Quest 3. The programme consisted of modified yoga postures targeting upper-limb mobility, shoulder movements, and thoracic expansion. The selected postures included Tadasana with arm elevation, Urdhva Hastasana, Virabhadrasana I, Virabhadrasana II, Ardha Chakrasana, modified Adho Mukha Svanasana, and Gomukhasana arm positioning. Each posture was performed in a seated/standing position and maintained for 8-10 seconds for three sets. A rest interval of 30 seconds was provided between postures. The intervention was conducted for 45 minutes per session, three sessions per week, over six weeks, resulting in 18 sessions. Participants were supervised by the physiotherapist throughout the intervention, and postures were modified according to individual tolerance and postoperative functional capacity. The Metaqueast app is used for VR applications, where a head-mounted display was used, symptoms of cybersickness were monitored, and sessions were stopped if significant symptoms occurred. The Simulator Sickness Questionnaire was identified in the original manuscript as a possible assessment tool [17].

Conventional exercise group

Participants allocated to the conventional yoga group performed the same modified yoga postures as those prescribed to the VR-based yoga group, without using a VR headset or immersive virtual environment. The exercises were taught through direct demonstration, verbal instructions, and supervision by a physiotherapist. The intervention followed the same six-week progressive exercise schedule, including the same postures, repetitions, sets, holding durations, rest intervals, and progression criteria as the VR group.

The programme included modified yoga postures targeting upper-limb mobility, shoulder movement, and thoracic expansion. Exercises were progressed across three phases: Weeks 1-2 (initial phase), Weeks 3-4 (intermediate phase), and Weeks 5-6 (advanced phase), according to the participants' tolerance and functional capacity. Each session lasted 45 minutes and was conducted three times per week for six weeks, resulting in 18 sessions. Participants were supervised by a physiotherapist throughout the intervention, and exercises were modified when required according to postoperative functional status and individual tolerance.

Outcome measures

Outcomes were assessed at baseline and after completion of the six-week intervention by an assessor blinded to group allocation.

Primary outcome: shoulder muscle strength

Isometric shoulder muscle strength was assessed using a hand-held dynamometer. The manuscript reports shoulder strength in kilograms. Shoulder muscle strength was assessed using a digital handheld dynamometer in a standardized sitting position. Four movements were evaluated: flexion, abduction, internal rotation, and external rotation. The dynamometer was applied to the distal forearm, with the elbow maintained at 90° during rotational testing. The examiner stabilized the trunk and shoulder to minimise compensatory movements. Strength values were recorded separately for each movement during pre- and post-intervention assessments using the same testing procedure. Three trials were recorded for each movement, with approximately 30 seconds of rest between trials, and the mean was used for analysis. Hand-held dynamometry has been reported to be reliable for assessing shoulder strength [18].

Secondary outcome: upper-limb function

Upper-limb function was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire [19]. The DASH score ranges from 0 to 100, with higher scores indicating greater disability and lower scores indicating less disability.

Other data

Age, sex, body mass index, hand dominance, session attendance, adverse events, withdrawals, and reasons for withdrawal were recorded.

Adverse events and participant withdrawals

No adverse events or exercise-related complications were reported in either group during the six-week intervention period. All 40 participants (20 in the VR-based yoga group and 20 in the conventional physiotherapy group) completed the intervention, and no participant withdrawals were recorded.

Statistical analysis

The manuscript states that data were analysed using the InStat application (GraphPad Software, Inc., San Diego, CA). Continuous variables were summarized using means and standard deviations when appropriate or medians and interquartile ranges when distributions were not appropriate for parametric summaries. Categorical variables were summarized as frequencies and percentages. The primary outcome was shoulder muscle strength, and the secondary outcome was the DASH score. Statistical analysis was performed using GraphPad InStat software. Normality of the data was assessed using the Shapiro-Wilk test. Within-group pre- and post-intervention differences were analyzed using a paired t-test, while between-group comparisons were performed using an independent t-test. No missing data were reported, and no baseline adjustment was performed. Within-group comparisons between pre-intervention and post-intervention values were performed using paired t-tests, while between-group comparisons were performed using independent t-tests. Statistical significance was set at $p < 0.05$.

Research ethics

This study was conducted at Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, after obtaining the necessary institutional permission. Ethical approval was obtained from the Institutional Ethics Committee of Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India (reference no.: KVV/IEC/04/2025). Written informed consent was obtained from all participants before enrolment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

Baseline characteristics

A total of 40 participants were included in the study, with 20 participants allocated to each group. The mean age was 68.1 ± 5.0 years in the VR-based yoga group and 67.8 ± 5.3 years in the conventional exercise group. The VR-based yoga group consisted of eight males (40%) and 12 females (60%), whereas the conventional exercise group consisted of nine males (45%) and 11 females (55%).

Exercise completion and adverse events

No adverse events or exercise-related complications were reported in either group during the intervention period. All 40 participants (20 in each group) completed the intervention, and no participant withdrawals were recorded.

At baseline, in Table 1, the mean shoulder muscle strength was 8.11 ± 0.73 kg in the VR-based yoga group and 8.01 ± 1.09 kg in the conventional exercise group. The mean DASH scores were 38.20 ± 7.86 and 37.36 ± 8.73, respectively. No statistically significant between-group differences were observed in age (independent samples t-test: t = 0.184, p = 0.855), shoulder muscle strength (t = 0.341, p = 0.735), or DASH scores (t = 0.320, p = 0.751). Gender distribution was also comparable between groups (Pearson chi-square test: $\chi^2 = 0.102$, p = 0.749). These findings indicate that the groups had comparable baseline demographic and clinical characteristics.

Variable	VR-based yoga (n=20)	Conventional exercise (n=20)	Test statistic	p-value
Age (years), mean ± SD	68.1 ± 5.0	67.8 ± 5.3	t = 0.184	0.855
Male, n (%)	8 (40%)	9 (45%)	$\chi^2 = 0.102$	0.749
Female, n (%)	12 (60%)	11 (55%)	-	-
Shoulder strength (kg), mean ± SD	8.11 ± 0.73	8.01 ± 1.09	t = 0.341	0.735
DASH score, mean ± SD	38.20 ± 7.86	37.36 ± 8.73	t = 0.320	0.751

TABLE 1: Baseline characteristics

% percentage; DASH: Disabilities of the Arm, Shoulder and Hand; VR: virtual reality

In Figure 1, both groups demonstrated an increase in shoulder muscle strength following the six-week intervention. The VR-based yoga group showed a greater numerical improvement compared with the conventional exercise group.

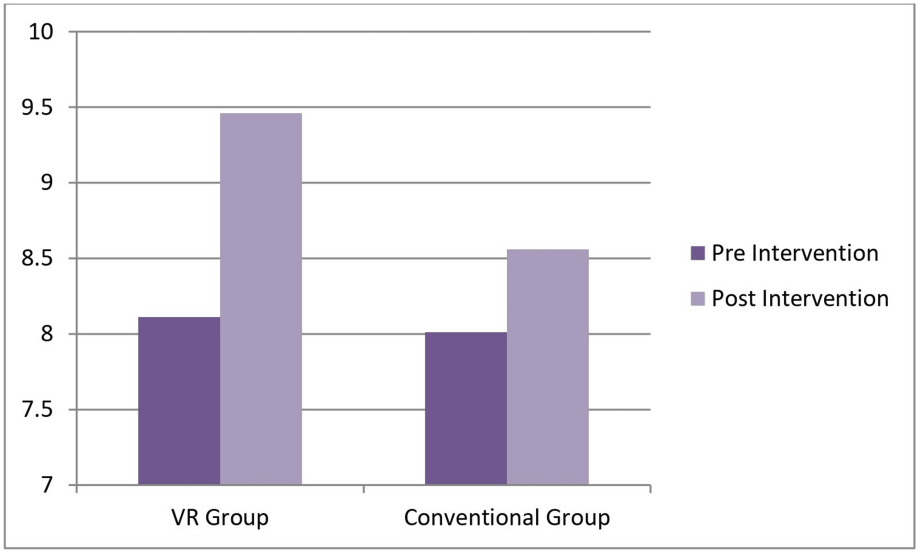


FIGURE 1: Shoulder strength (handhold dynamometer)

VR: virtual reality

In Table 2, shoulder muscle strength increased in both intervention groups following the six-week exercise programme. In the VR-based yoga group, mean shoulder muscle strength increased from 8.11 ± 0.73 kg at baseline to 9.46 ± 1.01 kg after the intervention, representing a numerical increase of 1.35 kg. In the conventional exercise group, the corresponding values increased from 8.01 ± 1.09 kg to 8.56 ± 1.12 kg, representing a numerical increase of 0.55 kg.

Outcome	VR-based yoga (n=20)	Conventional exercise (n=20)	Test statistic	p-value
Shoulder strength				
Pre-intervention	8.11 ± 0.73 kg	8.01 ± 1.09 kg	-	-
Post-intervention	9.46 ± 1.01 kg	8.56 ± 1.12 kg	t = 2.669	0.011
DASH				
Pre-intervention	38.20 ± 7.86	37.36 ± 8.73	-	-
Post-intervention	22.99 ± 8.30	31.53 ± 9.81	t = -2.972	0.005

TABLE 2: Outcome findings

DASH: Disabilities of the Arm, Shoulder and Hand; VR: virtual reality

At post-intervention, shoulder muscle strength was significantly higher in the VR-based yoga group than in the conventional exercise group (independent samples t-test: t = 2.669, p = 0.011).

Upper-limb function was evaluated using the DASH questionnaire. The mean DASH score in the VR-based yoga group decreased from 38.20 ± 7.86 at baseline to 22.99 ± 8.30 after the intervention, representing a numerical reduction of 15.21 points. In the conventional exercise group, the mean score decreased from 37.36 ± 8.73 to 31.53 ± 9.81, representing a numerical reduction of 5.83 points.

At post-intervention, the VR-based yoga group demonstrated significantly lower DASH scores compared with the conventional exercise group (independent samples t-test: t = -2.972, p = 0.005). Since lower DASH scores indicate less upper-limb disability, these findings suggest greater improvement in upper-limb function in the VR-based yoga group compared with the conventional exercise group.

Figure *2* represents the pre- and post-intervention DASH scores in both groups. A reduction in DASH scores was observed following the intervention in both groups, indicating improvement in upper-limb function and a reduction in disability.

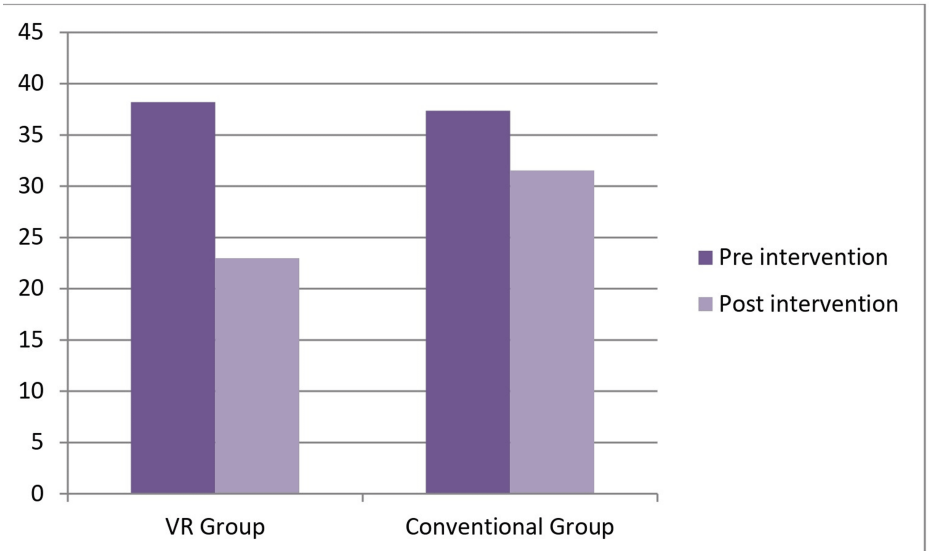


FIGURE 2: Pre- and post-intervention DASH scores in both groups

DASH: Disabilities of the Arm, Shoulder and Hand; VR: virtual reality

Discussion

This prospective interventional study compared the effects of VR-based yoga and conventional physiotherapy shoulder exercises on shoulder muscle strength and upper-limb function in older adults aged

60-75 years following CABG surgery over a six-week intervention period. Both groups demonstrated numerical improvements in shoulder muscle strength and reductions in DASH scores following the intervention. However, the magnitude of the descriptive changes was greater in the VR-based yoga group. These findings provide preliminary information regarding the potential application of VR-based yoga as an alternative exercise-delivery approach for shoulder rehabilitation in older adults following CABG surgery.

Shoulder muscle strength increased by 1.35 kg in the VR-based yoga group compared with 0.55 kg in the conventional exercise group. This numerical improvement may be associated with the structured movement patterns, sustained muscle activation, and repeated shoulder movements involved in the selected yoga postures. The integration of VR technology may also provide visual guidance and interactive feedback during exercise performance. These features could support exercise participation and movement awareness among older adults. Nevertheless, the specific mechanisms responsible for the observed changes were not directly investigated and require further evaluation. Previous research has identified potential benefits of resistance training and yoga for improving selected physical outcomes in older adults [4,11].

Upper-limb function, assessed using the DASH questionnaire, also improved numerically in both groups. The VR-based yoga group demonstrated a reduction of 15.21 points, whereas the conventional exercise group demonstrated a reduction of 5.83 points. Lower DASH scores indicate fewer symptoms and reduced upper-limb disability. These changes may reflect improvements in the perceived ability to perform daily activities involving reaching, lifting, dressing, grooming, and other upper-extremity movements. However, the clinical importance of these changes should be interpreted with reference to the established minimal clinically important difference and the characteristics of the study population. The DASH questionnaire provides a standardized assessment of upper-extremity symptoms and functional limitations [19].In the context of post-CABG rehabilitation, improvements in upper-limb function may be particularly relevant because shoulder mobility and functional use of the upper extremities contribute to the performance of routine daily activities during postoperative recovery.

The interactive nature of VR-based exercise may provide an additional dimension to conventional exercise delivery. Visual demonstrations, guided movements, and an immersive environment may help participants engage with structured exercise activities. Selected yoga postures involving shoulder flexion, abduction, and shoulder-girdle stabilization may provide opportunities for repeated movement practice. Previous studies have explored the feasibility, acceptability, and potential benefits of VR-based exercise in older adults [12-14]. However, improvements in balance, mobility, and psychological outcomes reported in previous studies cannot be directly extrapolated to shoulder muscle strength. Further research is therefore required to establish the specific contribution of VR-based yoga to shoulder rehabilitation, particularly among older adults recovering from CABG surgery.

Conventional physiotherapy shoulder exercises also demonstrated numerical improvements in muscle strength and upper-limb function. Progressive therapeutic exercise remains an established component of rehabilitation for older adults, as it can be adapted according to individual functional capacity and exercise tolerance. The improvements observed in the conventional exercise group highlight the continued relevance of structured physiotherapy interventions in geriatric rehabilitation. Previous evidence supports the importance of appropriately prescribed therapeutic exercises for maintaining and improving muscle strength in older populations, including those undergoing postoperative rehabilitation [4].

An important strength of this study was the comparison of two different exercise-delivery approaches using a randomized controlled design. Shoulder muscle strength was assessed quantitatively using a hand-held dynamometer, while upper-limb disability was evaluated using the DASH questionnaire. These complementary measures provided information about physical performance and self-reported functional limitations. The use of an assessor-blinded design may also have reduced the potential for measurement bias, provided that assessor blinding was maintained throughout the study.

Several limitations should be acknowledged. First, the relatively small sample size of 40 participants may limit the precision and generalizability of the findings. Second, participants and treating physiotherapists could not be blinded because of the nature of the interventions, potentially introducing performance and expectation bias. Third, the six-week intervention period did not allow assessment of the long-term maintenance of improvements. Differences in participants' baseline functional capacity, familiarity with VR technology, and individual responses to exercise may also have influenced the outcomes. Furthermore, the findings from this study should be interpreted in the context of the population and setting in which the intervention was delivered. The study was limited to older adults following CABG surgery; therefore, the findings may not be directly generalizable to the broader geriatric population or individuals with other musculoskeletal conditions.

Although no adverse events or exercise-related complications were reported during the intervention period, formal assessment of exercise adherence and long-term safety was limited. Future studies should incorporate standardized adherence monitoring, systematic adverse-event documentation, and longer follow-up to establish the feasibility and safety of VR-based rehabilitation in older adults following CABG

surgery.

Overall, both VR-based yoga and conventional physiotherapy shoulder exercises were associated with numerical improvements in shoulder muscle strength and upper-limb function among older adults following CABG surgery. Greater descriptive improvements were observed in the VR-based yoga group. However, comparative effectiveness and clinical superiority should only be established through appropriate between-group statistical analyses, effect estimates, confidence intervals, and consideration of clinically meaningful changes.

Limitations

The study has certain limitations. First, the relatively small sample size of 40 participants may limit the generalizability of the findings and the ability to detect smaller between-group differences. Second, the six-week intervention period may not be sufficient to establish the long-term effects of VR-based yoga on shoulder muscle strength and upper-limb function. Third, participants and treating therapists could not be blinded because of the nature of the intervention, although outcome assessment was blinded. Additionally, the findings may be influenced by individual differences in exercise performance and adherence. Further multicentre randomized controlled trials with larger sample sizes, standardized intervention protocols, and longer follow-up periods are recommended.

Clinical implications

VR-based yoga may offer an interactive and engaging approach to delivering shoulder-related exercises in older adults following CABG surgery. It may be considered an additional exercise-delivery option within postoperative cardiac rehabilitation, subject to individual clinical assessment, appropriate consideration of postoperative precautions, safety considerations, and professional supervision. The present findings do not establish that VR-based yoga should replace conventional physiotherapy exercises.

Conclusions

Both VR-based yoga and conventional yoga exercises demonstrated improvements in shoulder muscle strength and upper-limb function following the six-week intervention. The VR-based yoga group showed greater numerical improvements in shoulder muscle strength and DASH scores compared with the conventional exercise group. However, the comparative effectiveness of the interventions should be interpreted cautiously, considering the need for baseline-adjusted analysis and the clinical significance of the observed changes. These preliminary findings suggest that VR-based yoga may be a promising adjunct to conventional physiotherapy exercises for improving shoulder function and upper-limb mobility. Further studies with larger sample sizes and appropriate baseline-adjusted analyses are warranted to establish its comparative effectiveness.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Satyam S. Bhodaji, Pratiksha B. Kolekar

Acquisition, analysis, or interpretation of data: Satyam S. Bhodaji, Pratiksha B. Kolekar

Drafting of the manuscript: Satyam S. Bhodaji, Pratiksha B. Kolekar

Critical review of the manuscript for important intellectual content: Satyam S. Bhodaji, Pratiksha B. Kolekar

Supervision: Satyam S. Bhodaji, Pratiksha B. Kolekar

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Krishna Vishwa Vidyapeeth IRB issued approval KVV/IEC/04/2025. The institutional ethical committee has hereby given permission to initiate the research project. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **AI use statement:** The authors have declared that no AI tools were used during the work or in the drafting of this article. The authors take full responsibility for the work. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the

previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Janssen I, Heymsfield SB, Ross R: Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc. 2002, 50:889-96. 10.1046/j.1532-5415.2002.50216.x
2. Cruz-Jentoft AJ, Bahat G, Bauer J, et al.: Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019, 48:16-31. 10.1093/ageing/afy169
3. Chard MD, Hazleman R, Hazleman BL, King RH, Reiss BB: Shoulder disorders in the elderly: a community survey. Arthritis Rheum. 1991, 34:766-9. 10.1002/art.1780340619
4. Borde R, Hortobágyi T, Granacher U: Dose-response relationships of resistance training in healthy old adults: a systematic review and meta-analysis. Sports Med. 2015, 45:1693-720. 10.1007/s40279-015-0385-9
5. Youkhana S, Dean CM, Wolff M, Sherrington C, Tiedemann A: Yoga-based exercise improves balance and mobility in people aged 60 and over: a systematic review and meta-analysis. Age Ageing. 2016, 45:21-9. 10.1093/ageing/afv175
6. Chobe S, Chobe M, Metri K, Patra SK, Nagaratna R: Impact of Yoga on cognition and mental health among elderly: a systematic review. Complement Ther Med. 2020, 52:102421. 10.1016/j.ctim.2020.102421
7. Skjæret N, Nawaz A, Morat T, Schoene D, Helbostad JL, Vereijken B: Exercise and rehabilitation delivered through exergames in older adults: an integrative review of technologies, safety and efficacy. Int J Med Inform. 2016, 85:1-16. 10.1016/j.ijmedinf.2015.10.008
8. Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Chapman M, Crotty M: Virtual reality for stroke rehabilitation. Cochrane Database Syst Rev. 2025, 6:CD008349. 10.1002/14651858.CD008349.pub5
9. Rizzo AA, Kim GJ: A SWOT analysis of the field of virtual reality rehabilitation and therapy . Presence Teleoperators & Virtual Environments. 2005, 14:119-46.
10. Bull FC, Al-Ansari SS, Biddle S, et al.: WHO Guidelines on Physical Activity and Sedentary Behaviour . World Health Organization, Geneva, Switzerland; 2020.
11. Ko KY, Kwok ZC, Chan HY: Effects of yoga on physical and psychological health among community-dwelling older adults: a systematic review and meta-analysis. Int J Older People Nurs. 2023, 18:e12562. 10.1111/opn.12562
12. Doré B, Gaudreault A, Everard G, Ayena JC, Abboud A, Robitaille N, Batcho CS: Acceptability, feasibility, and effectiveness of immersive virtual technologies to promote exercise in older adults: a systematic review and meta-analysis. Sensors (Basel). 2023, 23:2506. 10.3390/s23052506
13. Vasodi E, Saatchian V, Dehghan Ghahfarokhi A: Virtual reality-based exercise interventions on quality of life, some balance factors and depression in older adults: a systematic review and meta-analysis of randomized controlled trials. Geriatr Nurs. 2023, 53:227-39. 10.1016/j.gerinurse.2023.07.019
14. Lee J, Phu S, Lord SR, Okubo Y: Effects of immersive virtual reality training on balance, gait and mobility in older adults: a systematic review and meta-analysis. Gait Posture. 2024, 110:129-37.
15. Schulz KF, Altman DG, Moher D: CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010, 340:c332. 10.1136/bmj.c332
16. Borg GA: Psychophysical bases of perceived exertion . Med Sci Sports Exerc. 1982, 14:377-81.
17. Kennedy RS, Lane NE, Berbaum KS, Lilienthal MG: Simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. Int J Aviat Psychol. 1993, 3:203-20. 10.1207/s15327108ijap0303_3
18. Hayes K, Walton JR, Szomor ZR, Murrell GA: Reliability of 3 methods for assessing shoulder strength . J Shoulder Elbow Surg. 2002, 11:33-9.
19. Hudak PL, Amadio PC, Bombardier C: Development of an upper extremity outcome measure: the DASH (Disabilities of the Arm, Shoulder and Hand). Am J Ind Med. 1996, 29:602-8.