

Archives of ALLIED HEALTH SCIENCES

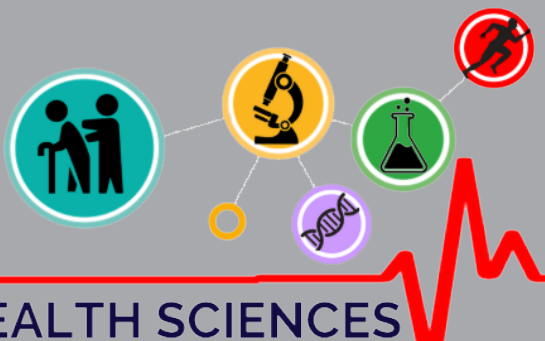
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The effect of breath-holding and Valsalva manoeuvre on pain: a systematic review and meta-analysis

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KEYWORDS

Valsalva manoeuvre;
Breath-holding;
Hypoalgesia;
Baroreflex;
Pain Management.

ABSTRACT

Breath-holding and the Valsalva manoeuvre are simple, non-pharmacological techniques that may modulate pain through autonomic and cardiovascular mechanisms. However, their effects on pain have not been systematically synthesized. This systematic review and meta-analysis aimed to evaluate the effect of breath-holding and the Valsalva manoeuvre on pain intensity. Electronic searches were conducted in PubMed, ScienceDirect, Embase, Scopus, and the Cochrane Library for studies published between 1996 and 2025. Experimental and quasi-experimental studies investigating breath-holding, breath retention, or the Valsalva manoeuvre with pain intensity as the primary outcome were included. Two reviewers independently screened studies and assessed methodological quality using the Downs and Black checklist. A random-effects meta-analysis was performed. Of 8,266 records identified, four studies involving 102 healthy young adults met the inclusion criteria for qualitative synthesis, and three studies involving 64 healthy young adults were included in the meta-analysis. All studies were rated as fair methodological quality. Meta-analysis showed that breath-holding significantly reduced pain intensity compared with normal breathing, with a pooled effect size of -0.93 on a 10-point pain scale (95% CI: -1.06 to -0.80 ; p -value < 0.001 ; $I^2 = 0.00\%$). However, the certainty of evidence was rated as very low (GRADE), and effect sizes did not reach established minimal clinically important differences. Pain reduction was observed across most experimental pain models, although findings were condition-specific in thermal pain. These preliminary findings suggest that breath-holding may reduce pain intensity in healthy young adults, potentially through baroreceptor activation and vagal modulation. Further high-quality randomised controlled trials in diverse clinical populations are required to establish clinical effectiveness, safety, and applicability.

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Introduction

Pain is widely undertreated, causing suffering and financial loss to individuals and society. The International Association for the Study of Pain defines pain as “an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage”⁽¹⁾. Underlying causes of pain can be divided into nociceptive pain, neuropathic pain, and psychogenic pain. Therefore, pain management strategies should be tailored to the specific underlying causes of the pain⁽²⁻⁴⁾.

Psychological factors significantly influence pain, as there is a reciprocal relationship between pain and stressors; pain can precipitate stress, while stress can further intensify pain^(2,3,5). The presence of pain or stressors can alter breathing patterns, potentially leading to acute hyperventilation. This condition results in hypocapnia, respiratory alkalosis, and heightened sympathetic nervous system activity, which can induce pain, fatigue, and muscle tension affecting musculoskeletal functions⁽⁵⁾.

Breathing techniques can be used as a strategy for managing pain associated with these conditions^(6,7). Breathing techniques, such as the Buteyko method, Feldenkrais, yoga breathing (pranayama), and the 4-7-8 breathing exercise, are commonly used to manage stress and hyperventilation. These methods typically involve breath-holding as a key component of the breathing cycle^(5,8).

Recent reviews have extensively examined the effects of slow breathing techniques. They found that slow breathing influence on chemoreflex and baroreflex sensitivity, heart rate variability (HRV), and sympathovagal balance⁽⁹⁾. It has also been shown to reduce the perceived intensity of pain from thermal stimuli⁽¹⁰⁾ and modulates sympathetic arousal and pain perception⁽¹¹⁾. A systematic review on the relationship between respiration and pain found that slow deep breathing helps to reduce pain; however, the physiological mechanisms remain uncertain^(7,12).

A systematic review and meta-analysis found that slow breathing influences the parasympathetic nervous system⁽¹³⁾. Another meta-analysis reported a significant effect size of -0.68 on the visual analogue scale (VAS) for reducing acute pain⁽¹⁴⁾. Similarly, breathing exercises, either alone or in combination with other interventions, significantly reduced pain (VAS = -0.57) in patients with low back pain⁽¹⁵⁾.

Breath-holding practices have also been shown to induce physiological adaptations, including changes in stress hormones, blood acidosis, and immune responses⁽¹⁶⁻¹⁸⁾. In 2005, Agarwal et al.⁽¹⁹⁾ observed that performing the Valsalva manoeuvre during venous cannulation significantly reduces pain. Reyes del Paso et al.⁽²⁰⁾ found that pain perception is reduced when painful stimulation is applied during breath-holding immediately after a deep inhalation, accompanied by increased blood pressure and decreased heart rate, mediated by the activation of the baroreceptor reflex and its vagal efferent response. However, the specific effects of breath-holding on pain remain unclear.

From the existing literature, it is evident that a systematic review and meta-analysis on the effects of breath-holding on pain are still lacking. Therefore, the present study aimed to evaluate the effects of breath-holding and Valsalva manoeuvre on pain intensity.

Materials and Methods

Data source and search strategy

Electronic searches were performed in PubMed (National Library of Medicine, NIH), ScienceDirect, Embase, Scopus, and Cochrane, for studies published between 1996 and 2025 with the final searches conducting in November 2024. Unpublished studies were intended to be identified through grey literature sources, including GreyNet International, the Grey Literature Network Service, and the International Clinical Trials Registry Platform (ICTRP); however, the OpenGrey website (<http://opengrey.edu/>) is no longer accessible.

Studies were included based on the pre-defined PICO (Population, Intervention, Comparison, and Outcome) eligibility criteria regardless of the original study's primary objective, provided that breath-holding was performed as an intervention and pain intensity was measured and reported as an outcome. For PubMed, ScienceDirect, Embase, and Cochrane Library, the following search terms were used: ("Breath-holding" OR "Breath retention" OR "Valsalva manoeuvre") AND Pain NOT (animal). For Scopus, the following search strategy was applied: ("Breath-holding" OR "Breath retention" OR "Valsalva manoeuvre") AND Pain. Both sets of search strategies were additionally applied to search for unpublished articles. Two reviewers (CP and PN) independently searched for articles and screened the titles, abstracts, and the full articles of potentially relevant papers. Following the selection of eligible articles, the reference lists of included articles were also reviewed to identify any additional relevant articles.

Eligibility criteria

The selection criteria of the relevant articles were:

- a) The intervention involved breath-holding, breath retention, or Valsalva manoeuvre techniques. Studies involving venipuncture techniques were excluded. The study utilized an experimental and quasi-experimental design. Observational studies, case reports, and case series were excluded.
- b) The primary outcome was pain intensity or pain perception.
- c) There were no restrictions regarding country, participant age, or gender.
- d) The article was a full report published in English. Proceeding paper, Thesis and Protocol studies were excluded.

Data extraction

The data extraction encompassed a thorough overview of study characteristics, population demographics, sample sizes, interventions, comparisons, outcomes, and study results. It

was conducted in alignment with the specific research questions. To minimize bias and reduce errors, two reviewers (CP and PN) independently evaluated the articles, any disagreements were resolved through discussion, and when consensus could not be reached, a third reviewer (WJ) was consulted. The accuracy of the data extraction was subsequently confirmed by WJ.

Risk of bias assessment

The methodological quality of the included articles was evaluated independently by two reviewers (KA and RP) using The Downs and Black quality assessment tool, a 27-item checklist designed to assess randomised and non-randomised study design⁽²¹⁾. The highest possible score is 28, with higher scores indicating better methodological quality. Scores of 26-28 are considered as excellent, 20-25 as good, 15-19 as fair, and scores below 14 as poor⁽²¹⁾. The item-by-item ratings from the two reviewers were compared, and any disagreements were resolved through discussion. When consensus could not be reached, a third reviewer (WJ) was consulted to provide the final judgment. Each item on the checklist is scored 0 (No) or 1 (Yes), except for item five, which is scored on a scale of 0 to 2 (2 = Yes, 1 = Partially, 0 = No). The final item, which addresses sample power, is also scored from 0 to 1 (1 = Yes, 0 = No, or unable to determine = 0).

The overall certainty of evidence was assessed using the GRADE approach, evaluating risk of bias, inconsistency of results, indirectness of evidence, imprecision of effect estimates, and publication bias^(22,23). The certainty of evidence was categorized into four levels: high, moderate, low, and very low. Downgrading was applied when concerns were identified in any of these domains, with one, two, or three levels of downgrading corresponding to moderate-, low-, or very low-certainty evidence, respectively. High-certainty evidence indicates that further research is unlikely to change confidence in the estimated effect. Moderate-certainty evidence suggests that additional research may have an important impact on confidence in the estimate and may change the

effect estimate. Low-certainty evidence indicates that further research is very likely to substantially affect confidence in the estimate and is likely to change the effect estimate, whereas very low-certainty evidence reflects substantial uncertainty about the estimated effect^(23,24).

Data synthesis and analysis

For studies eligible for quantitative analysis, standard meta-analysis procedures were applied to estimate the overall effect of breath-holding on pain intensity. Although all studies used repeated-measures designs, raw paired data and within-subject correlation coefficients were not consistently reported. As a result, mean differences were calculated using post-intervention values, which may have overestimated the precision of the pooled effect. This limitation was considered in the interpretation of the findings⁽²⁵⁾. A random-effect model was selected a priori to account for methodological variability across studies, including differences in pain induction methods, breath-holding duration, and outcome measurement tools. This analysis was performed using a user-written command in Stata/SE version 18.0 (StataCorp, College Station, TX, USA)⁽²⁶⁾.

Q-statistics and *p*-values were employed to evaluate the statistical heterogeneity of outcomes among the studies. A substantial *Q*-statistic in relation to its degrees of freedom, along with a low *p*-value, suggests the presence of heterogeneity in the effects of the intervention^(27,28). *I*² values were categorized as follows: 25% or less indicates low heterogeneity, around 50% indicates moderate heterogeneity, and 75% or more signifies high heterogeneity⁽²⁵⁾. These heterogeneity indices will be presented in forest plots to visually represent variation in study results. If heterogeneity exceeds 50%, subgroup analysis will be performed to further explore potential sources of variation⁽²⁸⁾.

For articles that did not report numerical values but presented data in graphical form, WebPlotDigitizer software was used to extract the data points⁽²⁸⁾. Two independent (CP and PN) reviewers performed the extraction. Any

discrepancies between the reviewers were resolved through discussion and consensus, with final decisions made in consultation with the major advisor (WJ). To ensure consistency in data analysis, numerical rating scale (NRS) scores (0-100 scale) were converted to match the VAS scale (0-10) by dividing by 10. Furthermore, standard deviations (SD) were transformed into standard errors (SE) to facilitate statistical comparison across studies. The effect size is reported as a mean difference on the 10-point VAS score rather than a standardised effect size, as all studies were converted to a common scale prior to pooling, rendering further standardisation unnecessary.

For studies reporting means and standard deviations for each condition separately^(30,31), the standard error of the mean difference was calculated using the paired formula to account for the repeated measures design of all included studies, with an assumed within-subject correlation coefficient of $r = 0.5$, a conservative and commonly used assumption in meta-analytic literature when within-subject correlations are not reported in the original studies. The formula applied was:

$$SE = \sqrt{(SD_1^2 + SD_2^2 - 2 \times r \times SD_1 \times SD_2) \div n}$$

where SD_1 and SD_2 are the standard deviations of the intervention and control conditions respectively, r is the assumed within-subject correlation coefficient, and n is the sample size. For Jafari et al.⁽²⁹⁾, the mean difference and standard error were taken directly from the original paper, as these values were reported using multilevel modelling, and both were divided by 10 to convert from NRS (0-100) to VAS (0-10) score prior to analysis.

A leave-one-out sensitivity analysis confirmed the robustness of these findings, random-effects REML model applied throughout.

Publication bias could not be assessed because fewer than 10 studies were included,

which makes such an evaluation statistically unreliable⁽²⁸⁾.

Results

Selection of study

The search identified 8,266 studies based on titles and abstracts. After removing duplicates (1,559 articles) and excluding irrelevant studies (6,692 articles), 15 potentially eligible full-text articles remained. These full-text articles were assessed according to the inclusion and exclusion criteria, of which four studies were included in the qualitative synthesis and three in the meta-analysis^(20,29-31). The assessment of inter-rater reliability for article selection by the two reviewers resulted in a kappa value of 0.842, which indicates excellent agreement (p -value = 0.001). Any discrepancies were addressed by third reviewer (WJ). The overall search strategy and selection process were illustrated in the PRISMA flow chart (Figure 1).

Additionally, a search of grey literature found no related articles. A manual search on PubMed was also conducted to identify relevant articles associated with the four papers selected after the title and abstract screening; however, no related articles were found.

Characteristics of the study

The sample descriptions are reported in Table 1. In total, 102 healthy individuals aged 18 to 28 years were included, with no significant differences reported at baseline^(20,29-31). There was one quasi-experimental study (one with a pretest-posttest non-randomised control condition design)⁽²⁰⁾ and three repeated measures design⁽²⁹⁻³¹⁾.

All studies involved an intervention in which participants performed breath-holding for either 4 seconds or as long as possible^(20, 29-31). One study included a control condition that performed slow breathing⁽²⁰⁾, while three studies used normal breathing as a comparator for the intervention⁽²⁷⁻²⁹⁾. The primary outcome measure across the studies was pain assessment, using VAS (0-10 scale)^(20,30,31) and NRS (0-100 scale)⁽²⁹⁾.

Each study employed different methods of pain induction, as follows: pressure pain was applied using an algometer on the finger nails⁽²⁰⁾, electrocutaneous stimuli were delivered to the sural nerve using a Digitimer DS5⁽²⁹⁾, intramuscular injection of glutamate was used to induce muscle pain⁽³⁰⁾, and thermal pain was induced by immersion of hand in either hot water (47°C) or cold water (7°C or 12°C)⁽³²⁾.

Measurements were taken both before and after the intervention in all studies^(20,29-31). There was an interval of one week between each session⁽³⁰⁾, and a 5-minute recovery period between individual test trials⁽³¹⁾.

A comparative analysis of pain scores across different studies revealed a significant reduction in pain (p -value < 0.001) in studies by Reyes del Paso et al.⁽²⁰⁾ and Jafari et al.⁽²⁹⁾, as well as a statistically significant reduction (p -value < 0.05) in the study by Drummond⁽³¹⁾. However, no significant difference was found between the two groups, latent myofascial trigger points (MTrP) injection with normal breathing and MTrP injection combined with breath-holding in the study by Kimura et al.⁽³⁰⁾ (p -value = 0.113).

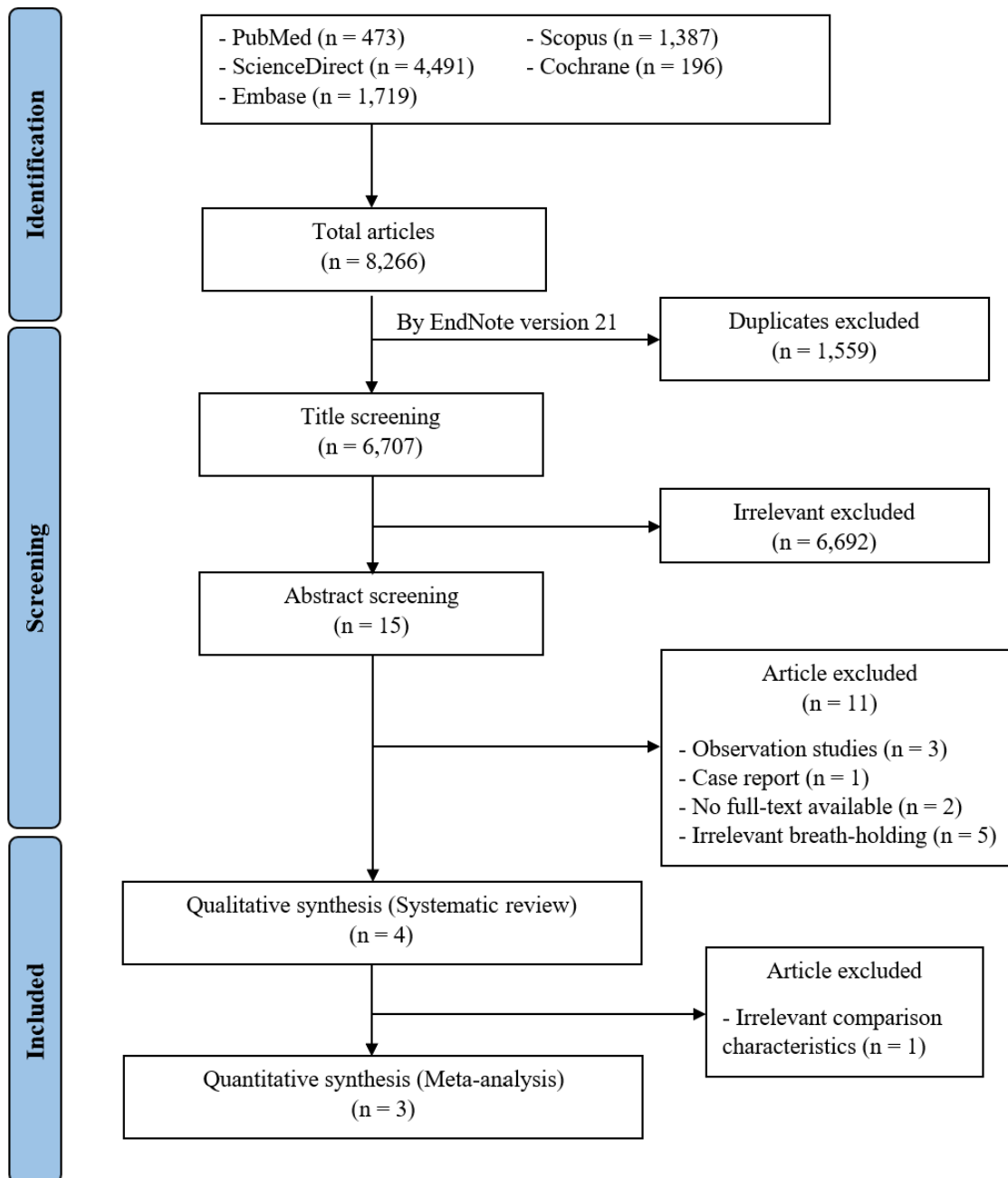


Figure 1 Flow diagram of the searching and screening process

Table 1 Study characteristics

Author	Study design	Study population	Intervention	Outcome	Measurement	Time of measurement	Result: (p-value)
Reyes del Paso et al. ⁽²⁰⁾	Quasi-Experimental: pre-post non-randomised control group	38 Healthy students (18-23 y) I: n = 19 C: n = 19	I: Breath-holding (7 sec) C: Slow Breathing	Pain (VAS 0-10)	Pain pressure (algometer) press at finger nails.	Pre-Post (Immediately)	< 0.001**
Jafari et al. ⁽²⁹⁾	Randomised crossover	32 Healthy people (20.7±2.5 y)	I: Breath-holding (30 sec) C: Normal breathing	Pain (NRS 0-100)	Electrocutaneous stimuli (Digitimer DS5) of sural nerve	Pre-Post (Immediately)	< 0.001**
Kimura et al. ⁽³⁰⁾	Randomised crossover	14 Healthy people (24.33±3.42 y)	I: Breath-holding (as long as possible) C: Normal breathing	Pain (VAS 0-10)	Glutamate injection induces muscle pain in MTrP	Pre-Post (Immediately) Interval of 1 week in between each session	0.113
Drummond ⁽³¹⁾	Randomised crossover	18 Healthy people (28±12 y)	I: Valsalva manoeuvre (30 sec) C: Normal breathing	Pain (VAS 0-10)	Immersion of hand in hot (47°C) or cold water (7°C, 12°C)	Pre-Post (Immediately) Interval of 5 minutes recovery period in between each session	< 0.05* (7°C)

Note: RCT, Randomised control trial; MTrP, latent myofascial trigger point; sec, seconds; y, year; VAS, Visual Analogue Scale; NRS, Numerical Rating Scale;

°C, degree Celsius; sec, seconds; I, intervention condition; C, control condition; *, *p*-value < 0.05; **, *p*-value < 0.01.

Quality assessment and Risk of bias

The quality assessment of the four included articles was assessed using the Downs and Black quality checklist, which indicated the quality level of each article. All studies rated as “Fair” (16–17/28) suggest consistent but moderate quality (Table 2). Common weaknesses across studies were a lack of characteristics of subjects clearly described, distribution of principal confounders in each group clearly described,

participants recruited representative of the entire population, staff, places, and facilities where patients were treated representative of the majority of the population, blinding of study subjects and assessors, main outcome measures reliable and valid, concealed randomization to allocation undertaken, adequate adjustment made in the analysis of confounders, and sufficiently powered cohort size.

Table 2 Quality assessment of the four included articles was assessed using the Downs and Black quality checklist

Downs and Black quality checklist		Reyes del Paso et al. ²⁰	Jafari et al. ²⁹	Kimura et al. ³⁰	Drummond ³¹
1	Hypotheses/aims/objectives clearly described	1	1	1	1
2	Main outcome measures clearly described	1	1	1	1
3	Characteristics of patients/subjects clearly described	0	0	0	0
4	Interventions of interest clearly described	1	1	1	1
5	Distribution of principal confounders in each group clearly described	0	0	0	0
6	Main findings clearly described	1	1	1	1
7	Estimates of random variability in the data provided	1	1	1	1
8	Important adverse events reported	1	1	0	1
9	Characteristics of patients lost to follow-up describe.	1	1	1	1
10	Actual probability values reported	1	1	1	1
11	Participants approached representative of entire population	1	1	1	1
12	Participants recruited representative of entire population	0	0	0	0
13	Staff, places, and facilities were patients treated representative of majority of population	0	0	0	0
14	Blinding of study subjects	0	0	0	0
15	Blinding of assessors	0	0	0	0
16	Data based on data-dredging clearly stated	1	1	1	1
17	Time period between the intervention and outcome the same for cases and controls	1	1	1	1
18	Appropriate statistical tests used	1	1	1	1
19	Compliance to intervention reliable	1	1	1	1
20	Main outcome measures reliable and valid	1	0	0	0
21	Intervention groups or case-controls recruited from same population	1	1	1	1

Table 2 Quality assessment of the four included articles was assessed using the Downs and Black quality checklist (Cont.)

Downs and Black quality checklist		Reyes del Paso et al. ²⁰	Jafari et al. ²⁹	Kimura et al. ³⁰	Drummond ³¹
22	Intervention groups or case-controls recruited at the same time	1	1	1	1
23	Study subjects randomized to the interventions	0	1	1	1
24	Was concealed randomization to allocation undertaken	0	0	0	0
25	Adequate adjustment made in the analysis of confounders	0	0	0	0
26	Patient losses accounted for	1	1	1	1
27	Sufficiently powered cohort size	0	0	0	0
Total = 28		17	17	16	17

Note: (1 = Yes, 0 = No, unable to determine). Downs and Black score: excellent (26-28); good (20-25); fair (15-19); and poor (<14).

Certainty of evidence

Of the four studies that met the inclusion criteria, three employed a randomised crossover design and were included in the meta-analysis (Jafari et al.⁽²⁹⁾; Kimura et al.⁽³⁰⁾; Drummond⁽³¹⁾), while one was a non-randomised controlled study

(quasi-experimental design; Reyes del Paso et al.⁽²⁰⁾) included only in the qualitative synthesis. According to the GRADE approach, the overall certainty of evidence was rated as very low for both classifications (Table 3).

Table 3 Summary of Findings: Effect of breath-holding on pain intensity

Out come	No of participants (studies)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality of evidence (GRADE)
Pain intensity	64 (3 Randomised crossover)	Serious ¹	Not serious	Serious ³	Serious ⁴	Not serious	⊕○○○ Very low
Pain intensity	38 (1 non-RCT)	Serious ¹	Serious ²	Serious ³	Serious ⁴	Not serious	⊕○○○ Very low

Note: 1 Serious limitations of study design: complete absence of blinding of participants and assessors>25% of participants from studies with low-quality methods).

2 Serious inconsistency: only a single non-randomised study available for this classification).

3 Serious indirectness: all studies conducted in healthy participants with experimentally induced pain, limiting applicability to clinical pain populations

4 Serious imprecision: total sample size fewer than 400 participants in both classifications RCT, randomised control trial.

For the three randomised crossover studies, the certainty of evidence was downgraded from high to very low for three reasons. First, serious risk of bias was identified, as all three studies scored zero on blinding of participants (Item 14), blinding of assessors (Item 15), allocation concealment (Item 24), and adequacy of sample size (Item 27) on the Downs and Black checklist; limitations that are particularly consequential for subjective pain outcomes susceptible to expectation bias and demand characteristics. Second, serious indirectness was noted as all included studies were conducted exclusively in healthy young adults using experimentally induced pain, which substantially limits the applicability of findings to clinical pain populations. Third, serious imprecision was noted as the total sample size of 64 participants was well below the recommended threshold of 400 participants for GRADE imprecision assessment. No serious concerns were identified regarding inconsistency ($I^2 = 0.00\%$) or publication bias. Consequently, the certainty of evidence was rated as very low, indicating very limited confidence in the estimated effect and that the true effect may be substantially different from the estimated effect.

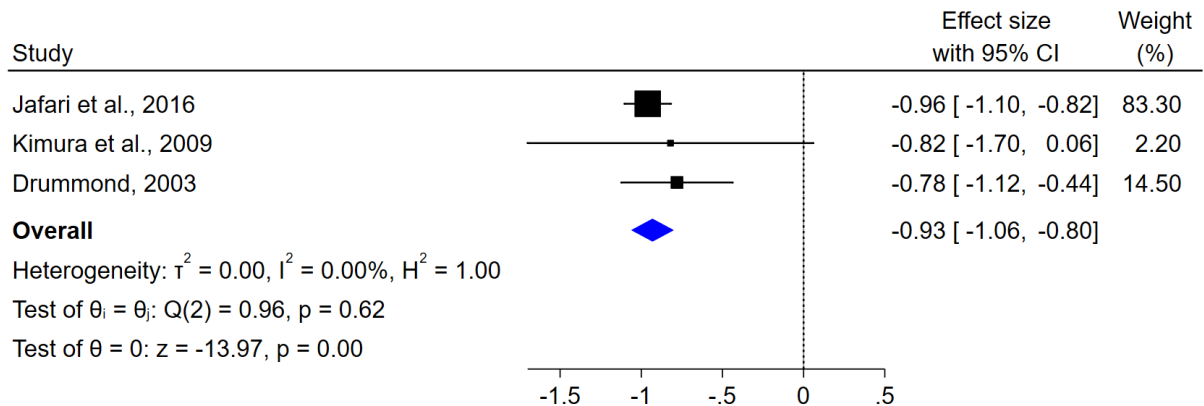
For the non-randomised controlled study⁽²⁰⁾, the certainty of evidence was also rated as very low. In addition to the serious risk of bias, indirectness, and imprecision noted above, serious inconsistency was identified as only a single non-randomised study was available for this classification, precluding meaningful assessment of consistency. No serious concerns were identified regarding publication bias. As a result, the certainty of evidence was rated as very low, indicating substantial uncertainty about the estimated effect, and these findings should be interpreted with considerable caution (Table 3).

Meta-analysis of the effect of breath-holding or Valsalva manoeuvre and normal breathing on pain

The study by Reyes del Paso et al.⁽²⁰⁾ was excluded from the meta-analysis due to differences in study design, as the control group employed slow breathing itself an active analgesic intervention, which was not comparable to the passive normal breathing control used in the other included studies. Therefore, to maintain consistency in comparison structure, only studies using a repeated-measures design with normal breathing as the control condition were included in the meta-analysis.

A meta-analysis was conducted to assess the overall impact of breath-holding and compared to normal breathing on pain intensity. Three randomised crossover studies enrolling healthy participants were included: Jafari et al.⁽²⁹⁾ ($n = 32$), Kimura et al.⁽³⁰⁾ ($n = 14$), and Drummond⁽³¹⁾ ($n = 18$), yielding a total pooled sample of 64 participants. Standard errors for Kimura et al.⁽³⁰⁾ and Drummond⁽³¹⁾ were calculated using the paired formula accounting for within-subject correlation, with an assumed correlation coefficient of $r = 0.5$, as within-subject correlations were not reported in the original studies. For Jafari et al.⁽²⁹⁾, the mean difference and standard error were taken directly from the original paper after conversion from NRS (0-100) to VAS (0-10) scale by dividing both values by 10.

The pooled mean difference in pain intensity was -0.93 points on a 10-point VAS scale (95% CI: -1.06 to -0.80 ; $p < 0.001$), indicating that breath-holding reduced pain intensity compared to normal breathing. Complete homogeneity was observed across studies ($Q = 0.96$, $p = 0.62$; $I^2 = 0.00\%$), suggesting that the effect was consistent across different experimental pain models and breath-holding protocols (Figure 2).

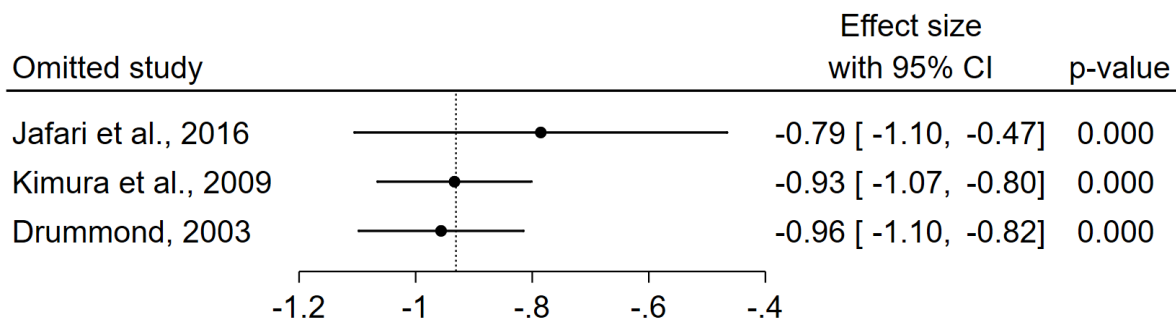


Random-effects REML model

Figure 2 The forest plot of effect of the breath-holding and normal breathing on pain**Sensitivity analysis**

To assess robustness of the findings, a leave-one-out sensitivity analysis was conducted. When Jafari et al. was excluded, the pooled effect remained statistically significant (-0.79;

95% CI: -1.10 to -0.47; $p < 0.001$) (Figure 3). Results were consistent across all leave-one-out scenarios, confirming that the pooled estimate is robust and not solely dependent on any single study.



Random-effects REML model

Figure 3 Leave-one-out sensitivity analysis of the effect of breath-holding on pain intensity. Each row displays the pooled effect size (95% CI) after omitting one study at a time. The vertical dash-line represents the overall pooled effect size from the primary analysis.**Discussion**

This systematic review and meta-analysis aimed to synthesize and analyze the available evidence on the effects of breath-holding on pain.

Quality assessment using the Downs and Black checklist showed that all studies were rated as fair (16-17 out of 28) (Table 2), reflecting moderate methodological quality. Item-level review revealed that all four included studies

scored zero on blinding of participants (Item 14), blinding of assessors (Item 15), allocation concealment (Item 24), adjustment for confounders (Item 25), and adequacy of sample size (Item 27). The complete absence of blinding across all studies is a critical limitation in the context of pain research, as self-reported VAS and NRS scores are particularly susceptible to expectation bias and demand characteristics. Furthermore, the

consistently small sample sizes across included studies, combined with the absence of blinding, increase the risk of effect size overestimation, a well-documented phenomenon in underpowered studies known as the small-study effect. These factors were explicitly considered in the GRADE assessment, which rated the overall certainty of evidence as very low, indicating that the true effect may be markedly different from the estimated pooled effect of -0.93 . While some of these methodological limitations may be unavoidable given the inherent nature of experimental pain research, particularly the impossibility of blinding participants to whether they are holding their breath, they underscore the need for improved methodological rigour in future studies, particularly regarding blinding of outcome assessors, adequate sample sizes, and allocation concealment.

The findings indicate that breath-holding significantly reduces perceived pain intensity. This outcome is consistent across various experimental pain models and is supported by evidence suggesting that breath-holding activates baroreceptors and modulates autonomic responses involved in pain inhibition.

Reyes del Paso et al.⁽²⁰⁾ demonstrated that breath-holding after a deep inhalation produced a notable reduction in pressure-induced pain across all intensity levels. This response was accompanied by increased blood pressure and decreased heart rate, indicating the activation of the baroreceptor reflex. Notably, this significant analgesic effect was achieved with a breath-holding duration of only 7 seconds, which is considerably shorter than the durations used in the other included studies (30 seconds in Jafari et al.⁽²⁹⁾ and as long as possible in Kimura et al.⁽³⁰⁾). This finding is clinically important as it suggests that even a brief breath-hold may be sufficient to elicit meaningful pain reduction, potentially lowering the barrier to practical application in clinical settings. Furthermore, the control condition in Reyes del Paso et al.⁽²⁰⁾ was slow breathing itself an active analgesic intervention

supported by existing literature rather than normal breathing as used in the other studies. This methodological difference means that the true analgesic effect of breath-holding in this study may have been underestimated, as it was compared against an active rather than a passive control. This distinction also explains why Reyes del Paso et al.⁽²⁰⁾ was excluded from the meta-analysis, where consistency of the control condition was required.

Jafari et al.⁽²⁹⁾ confirmed that breath-holding led to significant reductions in self-reported pain intensity, whereas the type of breath-hold (breath-holding at the end of expiration, mid-inhalation, or full-inhalation) had no significant effect on pain ratings. This supports the idea that the observed pain relief may be attributed to factors such as attentional focus, distraction, baroreceptor stimulation, or changes in vagal activity.

Although the primary aim of Kimura et al.⁽³⁰⁾ was to evaluate sympathetic vasoconstrictor responses to MTrP stimulation, this study met all four PICO eligibility criteria for inclusion in this review: participants were healthy adults, breath-holding was performed as the intervention, normal breathing was served as the control condition, and pain intensity was measured and reported as an outcome. Inclusion was therefore justified regardless of the original study's primary objective. The non-significant finding in Kimura et al.⁽³⁰⁾ contrasts with the significant analgesic effects observed in the other included studies and raises a clinically important question regarding pain-type specificity of BH-induced analgesia. The other studies employed cutaneous and superficial pain models, including electrical stimulation, pressure pain, and thermal pain, all of which yielded significant pain reduction with breath-holding. In contrast, Kimura et al.⁽³⁰⁾ used deep muscle pain induced by glutamate injection at latent MTrP, a fundamentally different nociceptive model. Baroreceptor-mediated hypoalgesia is thought to primarily inhibit spinal dorsal horn neurons processing cutaneous and superficial nociceptive

input⁽³³⁾. Deep muscle pain, however, is transmitted via A δ and C-fibre muscle afferents, which may be less susceptible to baroreceptor-mediated inhibition^(33,35). Furthermore, myofascial pain at trigger points involves peripheral sensitisation of deep tissue nociceptors, which may not be sufficiently modulated by the relatively brief cardiovascular changes induced by breath-holding⁽³⁶⁾. These observations suggest that blood pressure-induced analgesia may be more effective for cutaneous and superficial pain than for deep muscle or myofascial pain, a distinction that is critically relevant to physical therapy practice, where deep tissue pain conditions such as myofascial pain syndrome are commonly encountered. Future studies should directly compare the effects of breath-holding across different pain types to clarify this important clinical question.

Drummond⁽³¹⁾ studied the effects of Valsalva manoeuvre on thermal pain and found that it significantly reduced pain intensity in extremely cold environments (7°C), but had no significant effect in moderate cold or heat conditions. This suggests that baroreceptor activation from Valsalva manoeuvre alone may not be sufficient to produce substantial pain relief across all types of pain, particularly those induced by heat.

It is important to note that all included studies used experimentally induced pain in healthy participants, which allows for controlled mechanistic investigation but limits direct extrapolation to clinical pain conditions.

The mechanism to reduce pain confirms that both breath-holding and the Valsalva manoeuvre could decrease heart rate (approximately 10 bpm, reaching the peak reduction within 4 seconds)^(20,31) and increase blood pressure (approximately 4-5 mmHg, reaching the peak increase within 4 seconds)⁽²⁰⁾. Breath-holding increases blood pressure (due to positive intrathoracic pressure) and causes a rapid and pronounced slowing of heart rate (resulting from baroreceptor reflex activation and vagal responses)^(20,29,31). Consistent

with Reyes del Paso et al.⁽³²⁾, baroreceptor stimulation decreases heart rate and increases blood pressure. It also has the potential to produce an anti-nociceptive effect; however, a critical condition is that the stimulation must elicit a cardiovascular reflex response. If such a reflex is not induced, the pain-reducing effect will not occur. The degree of baroreceptor activation depends on the magnitude of blood pressure changes⁽³³⁾. An increase in blood pressure activates the parasympathetic system via the vagus nerve, leading to anti-inflammatory effects, engagement of serotonergic and noradrenergic pathways, and brain modulation, which together contribute to pain inhibition⁽³³⁻³⁵⁾. Nevertheless, alternative explanations, such as attentional mechanisms, predictive processes, or distraction from pain, cannot be excluded⁽²⁹⁾.

From four studies, no serious adverse events or side effects were reported from using the breath-holding for pain reduction. However, Hosseini et al.⁽³⁷⁾ studied the Valsalva manoeuvre performed during short peripheral cannula insertion in adults and concluded that it should be avoided in patients with retinopathy or intraocular lens implantation due to increased intraocular and intra-abdominal pressure. Although adverse events are rare, cases of syncope, chest pain, and arrhythmias have been reported. Caution is advised in patients with coronary artery disease, valvular heart disease, or congenital heart disease because of potential hemodynamic risks.

In addition to the systematic review, three of the four studies were included in the meta-analysis based on the homogeneity of participant groups, outcome measures, and comparison conditions⁽²⁹⁻³¹⁾. The meta-analysis demonstrated the effect size of breath-holding on pain intensity by comparing post-intervention values between the breath-holding and normal breathing. Publication bias could not be performed because the number of papers was fewer than 10⁽²⁸⁾.

The studies included in this meta-analysis involved 64 healthy participants aged 18-28

years⁽²⁹⁻³¹⁾, making the findings primarily applicable to young adults. While this age homogeneity supports internal validity, it limits generalizability to other age groups, such as adolescents or older adults, whose cardiovascular function and pain perception may differ significantly.

The meta-analysis revealed a significant effect size of -0.93 on a 10-point pain scale for breath-holding in reducing pain compared to normal breathing (p -value < 0.001), with complete homogeneity across studies ($I^2 = 0.00\%$). According to Cohen's conventional thresholds, where 0.20 is considered small, 0.50 medium, and 0.80 or above large⁽³⁸⁾, this effect size represents a large clinical effect. This magnitude suggests that breath-holding produces a substantial and clinically meaningful reduction in pain intensity, likely to be perceptible to patients, and may have practical implications as a non-pharmacological pain modulation strategy. These findings are consistent with the previous study by Hosseini et al.⁽³⁷⁾, which reported an effect size of -1.26 for pain intensity when the Valsalva manoeuvre was performed during short peripheral cannula insertion in adults. While breath-holding demonstrated a statistically significant and large effect size in experimental pain models, its clinical relevance remains uncertain, as the observed effect did not reach established minimal clinically important differences⁽³⁹⁾.

The observed statistical homogeneity was likely influenced by the repeated-measures design, similar participant characteristics, and highly comparable intervention and control conditions across the included studies.

All studies have consistently shown that breath-holding, with durations ranging from 4 seconds to as long as possible, may lead to a reduction in pain^(20,29-31), as baroreceptor activation and vagal stimulation appear to play a central role in hypoalgesia^(20,29-31), and the effect may also be influenced by attentional focus and distraction⁽²⁹⁾. Although Kimura et al.⁽³⁰⁾ reported a statistically non-significant reduction in pain, the

overall findings suggest that breath-holding offers a simple, non-invasive method for reducing pain, though its effectiveness may vary depending on the type of pain.

In this systematic review and meta-analysis, findings from both breath-holding and Valsalva manoeuvre were synthesized, although the level of intrathoracic pressure increase may differ between two techniques, which may affect the degree of baroreceptor stimulation. In rehabilitation settings, breath-holding and the Valsalva manoeuvre should be considered related but distinct techniques with different physiological demands. The Valsalva manoeuvre generates a greater increase in intrathoracic pressure and cardiovascular response than simple breath-holding, which may enhance baroreceptor-mediated hypoalgesia but also impose greater hemodynamic stress. Consequently, the risk profiles differ, and the Valsalva manoeuvre may be inappropriate for patients with cardiovascular disease, ocular conditions, or autonomic dysfunction commonly encountered in rehabilitation practice. In this review, both techniques were pooled pragmatically due to the limited number of eligible studies and their shared pain-modulating mechanism. Clinicians, particularly physical therapists, should apply these findings cautiously, integrating breath-holding primarily as a short-term adjunct during therapeutic activities and tailoring its use based on individual patient assessment until condition-specific evidence becomes available.

Clinical implications

Recent literature supports the use of breath-holding (30 seconds), which provides short-term pain relief, but the effect is temporary. It may be applied in combination with other techniques or exercises to reduce pain transiently during performance. These techniques should be avoided in patients with retinopathy or intraocular lens implantation, and used with caution in those with coronary artery disease, valvular heart disease, or congenital heart disease, due to

potential hemodynamic risks; rare adverse events include syncope, chest pain, and arrhythmias⁽³⁷⁾. Long-term efficacy and underlying mechanisms remain unclear, and further research is warranted.

Limitations of the study

Several methodological limitations of this review and the included studies should be considered when interpreting the findings. A critical methodological limitation across all four included studies was the complete absence of blinding of both participants and assessors, as evidenced by scores of zero on Items 14 and 15 of the Downs and Black checklist. In pain research, the absence of blinding is particularly consequential, as self-reported outcomes such as VAS and NRS scores are highly susceptible to expectation bias and demand characteristics, whereby participants may report reduced pain simply because they expect breath-holding to be effective. It should be noted, however, that blinding of participants to the breath-holding intervention is inherently impossible given the nature of the technique, which represents an unavoidable methodological constraint of this research area.

This limitation is further compounded by the small number of included studies, with only four eligibles for qualitative synthesis and three included in the meta-analysis, as well as generally small sample sizes. None of which were adequately powered as indicated by scores of zero on Item 27 of the Downs and Black checklist. It is well established in the meta-analysis literature that effect sizes derived from small, underpowered studies tend to overestimate the true effect, a phenomenon known as the small-study effect. Consequently, the pooled effect size of -0.93 reported in this meta-analysis should be interpreted with caution, as it may reflect an overestimate of the true analgesic effect of breath-holding. Although statistical heterogeneity was low ($I^2 = 0.00\%$), this likely reflects the limited number of studies and homogeneity of study populations rather than true consistency across broader contexts.

Additionally, more than 25% of the total participants were derived from studies with methodological limitations, which may further introduce bias and reduce the overall certainty of the evidence. These concerns were reflected in the GRADE assessment, which rated the certainty of evidence as very low.

All included studies focused on immediate pain relief and did not investigate long-term effects. Furthermore, all participants were young, healthy adults exposed to experimentally induced pain. While such models allow for controlled mechanistic investigation, they limit the generalisability of findings to clinical populations, particularly individuals with chronic or complex pain conditions commonly encountered in rehabilitation settings. Variability in pain induction methods including pressure, electrical stimulation, glutamate injection, and thermal stimuli also introduces heterogeneity in pain mechanisms. The non-significant finding in Kimura et al.⁽³⁰⁾ may reflect pain-type specificity of breath-holding-induced analgesia, whereby baroreceptor-mediated hypoalgesia may be more effective for cutaneous and superficial pain than for deep muscle or myofascial pain. This distinction limits the generalisability of the pooled findings to all pain types encountered in clinical practice, particularly in rehabilitation settings where deep tissue and myofascial pain conditions are commonly encountered. While baroreceptor activation and autonomic changes were suggested, not all studies directly measured baroreceptor sensitivity, heart rate variability (HRV), or sympathetic/ parasympathetic balance.

Several methodological concerns related to data handling should also be noted. Data extraction using WebPlotDigitizer may introduce minor inaccuracies. The conversion of NRS scores (0–100) from Jafari et al.⁽²⁹⁾ to the VAS score (0–10) by dividing by 10 assumes linear scalar equivalence between these instruments. While both mean difference and standard error were divided by the same factor to preserve the effect size ratio,

this assumption is not firmly established in the literature and represents an additional methodological limitation that should be considered when interpreting the pooled estimate. Furthermore, although within-subject correlation was accounted for using an assumed coefficient of $r = 0.5$ in the paired SE calculation, the true correlation was not available from the original studies, which introduces a degree of uncertainty in the precision of the pooled estimate.

Finally, this review was limited to English-language publications, and the small number of studies precluded formal assessment of publication bias. This systematic review was not prospectively registered in PROSPERO, which may increase the theoretical risk of post-hoc decision making. However, a protocol was developed a priori, PRISMA 2020 guidelines were followed throughout, and independent dual review was conducted at all stages to minimise this risk.

Future recommendations

A well-designed randomised controlled trial is essential to validate the effects of breath-holding on pain management before the technique can be broadly recommended. Future studies should aim to standardize research protocols, examine long-term outcomes, compare breath-holding with other non-pharmacological pain relief methods, and investigate the mechanism of pain relief. Importantly, research should also include participants from different age groups to determine whether age influences the effectiveness or physiological responses to breath-holding, thereby increasing the relevance and generalizability of the findings.

Conclusion

This systematic review and meta-analysis provide preliminary evidence that breath-holding

may reduce pain intensity in healthy young adults, likely through baroreceptor activation and vagal modulation. To our knowledge, this is the first systematic review and meta-analysis to specifically synthesize evidence on breath-holding and pain, with a pooled effect size of -0.93 (95% CI: -1.06 to -0.80 ; p -value < 0.001 , $I^2 = 0.00\%$) from three studies. However, the certainty of evidence was rated as very low (GRADE), and the observed effect size did not reach established minimal clinically important differences, limiting the applicability of these findings to clinical practice at this stage. These results should therefore be interpreted as exploratory, and breath-holding should not yet be broadly recommended as a clinical intervention. Further high-quality randomised controlled trials with diverse populations, standardized protocols, adequate sample sizes, blinding where feasible, and direct physiological measurements are needed to confirm clinical effectiveness, establish safety profiles, and elucidate underlying mechanisms.

Protocol and registration

This systematic review was not prospectively registered. The review protocol was developed a priori following PRISMA 2020 guidelines.

Ethical approval and consent to participate

Ethical approval was not required for this systematic review and meta-analysis as it involved analysis of previously published data available in the public domain. No primary data collection or patient recruitment was conducted. All included studies obtained appropriate ethical approval as reported in their respective publications.

Take home messages

Breath-holding is a simple, free, and non-invasive technique that may help reduce pain intensity in healthy adults, likely by activating the body's natural cardiovascular regulatory mechanisms. While current evidence is preliminary and based on experimental pain models in young healthy adults, it suggests that brief breath-holding could serve as a short-term supportive strategy alongside conventional pain management. Clinicians and patients should apply these findings cautiously, as further high-quality research in diverse clinical populations is needed before broad recommendations can be made.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

Kantheera Areerak: Conceptualization, Methodology, Validation, Supervision, Writing - original draft, Writing - review & editing.

Wattana Jalayondeja: Conceptualization, Methodology, Investigation, Data curation, Validation, Supervision, Writing - review & editing.

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Data availability

The data supporting the findings of this systematic review and meta-analysis are available from the included published studies cited in the References section. Additional data extraction forms and analysis files are available from the corresponding author upon reasonable request.

References

1. Raja SN, Carr DB, Cohen M, Finnerup NB, Flor H, Gibson S, et al. The revised International Association for the Study of Pain definition of pain: concepts, challenges, and compromises. *Pain* 2020; 161(9): 1976-82.
2. Dueñas M, Ojeda B, Salazar A, Mico JA, Failde I. A review of chronic pain impact on patients, their social environment and the health care system. *J Pain Res* 2016; 9: 457-67.
3. Annagür BB, Uguz F, Apiliogullari S, Kara I, Gunduz S. Psychiatric disorders and association with quality of sleep and quality of life in patients with chronic pain: a SCID-based study. *Pain Med* 2014; 15(5): 772-81.
4. Orr PM, Shank BC, Black AC. The role of pain classification systems in pain management. *Crit Care Nurs Clin North Am* 2017; 29(4): 407-18.
5. Chaitow L, Bradley D, Gilbert C. Recognizing and treating breathing disorders: a multidisciplinary approach. 2nd ed. Edinburgh: Churchill Livingstone; 2014.
6. Hamlin AS, Robertson TM. Pain and complementary therapies. *Crit Care Nurs Clin North Am* 2017; 29(4): 449-60.
7. Wang H, Liu XL, Wang T, Tan JY, Huang H. Breathing exercises for pain management in cancer survivors: a systematic review. *Pain Manag Nurs* 2023; 24(3): 299-310.
8. Vierra J, Boonla O, Prasertsri P. Effects of sleep deprivation and 4-7-8 breathing control on heart rate variability, blood pressure, blood glucose, and endothelial function in healthy young adults. *Physiol Rep* 2022; 10(13): e15389.

9. Russo MA, Santarelli DM, O'Rourke D. The physiological effects of slow breathing in the healthy human. *Breathe (Sheff)* 2017; 13(4): 298-309.
10. Zautra AJ, Fasman R, Davis MC, Craig ADB. The effects of slow breathing on affective responses to pain stimuli: an experimental study. *Pain* 2010; 149(1): 12-8.
11. Busch V, Magerl W, Kern U, Haas J, Hajak G, Eichhammer P. The effect of deep and slow breathing on pain perception, autonomic activity, and mood processing-an experimental study. *Pain Med* 2012; 13(2): 215-28.
12. Jafari H, Courtois I, Van den Bergh O, Vlaeyen JWS, Van Diest I. Pain and respiration: a systematic review. *Pain* 2017; 158(6): 995-1006.
13. Laborde S, Allen MS, Borges U, Dosseville F, Hosang TJ, Iskra M, et al. Effects of voluntary slow breathing on heart rate and heart rate variability: A systematic review and a meta-analysis. *Neurosci Biobehav Rev* 2022; 138: 104711.
14. Joseph AE, Moman RN, Barman RA, Kleppel DJ, Eberhart ND, Gerberi DJ, et al. Effects of slow deep breathing on acute clinical pain in adults: a systematic review and meta-analysis of randomized controlled trials. *J Evid Based Integr Med* 2022; 27: 2515690x221078006.
15. Shi J, Liu Z, Zhou X, Jin F, Chen X, Wang X, et al. Effects of breathing exercises on low back pain in clinical: a systematic review and meta-analysis. *Complement Ther Med* 2023; 79: 102993.
16. Djarova T, Ilkov A, Varbanova A, Nikiforova A, Mateev G. Human growth hormone, cortisol, and acid-base balance changes after hyperventilation and breath-holding. *Int J Sports Med* 1986; 7(6): 311-5.
17. Joulia F, Steinberg JG, Faucher M, Jamin T, Ulmer C, Kipson N, et al. Breath-hold training of humans reduces oxidative stress and blood acidosis after static and dynamic apnea. *Respir Physiol Neurobiol* 2003; 137(1): 19-27.
18. Kox M, van Eijk LT, Zwaag J, van den Wildenberg J, Sweep FC, van der Hoeven JG, et al. Voluntary activation of the sympathetic nervous system and attenuation of the innate immune response in humans. *Proc Natl Acad Sci U S A* 2014; 111(20): 7379-84.
19. Agarwal A, Sinha PK, Tandon M, Dhiraaj S, Singh U. Evaluating the efficacy of the valsalva manoeuvre on venous cannulation pain: a prospective, randomized study. *Anesth Analg* 2005; 101(4): 1230-2.
20. Reyes del Paso GA, Muñoz Ladrón de Guevara C, Montoro CI. Breath-holding during exhalation as a simple manipulation to reduce pain perception. *Pain Med* 2015; 16(9): 1835-41.
21. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998; 52(6): 377-84.
22. Furlan AD, Pennick V, Bombardier C, van Tulder M. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34(18): 1929-41.
23. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction- GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011; 64(4): 383-94.
24. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008; 336(7650): 924-6.
25. Lin L, Aloe AM. Evaluation of various estimators for standardized mean difference in meta-analysis. *Stat Med* 2021; 40(2): 403-26.
26. StataCorp. Statistical Software: Release 18. College Station (TX): StataCorp LLC; 2025.
27. Borenstein M, Hedges L, Higgins J, Rothstein H. Classifying Heterogeneity as Low, Moderate, or High. In: Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. *Introduction to Meta-Analysis*. 2nd ed. Chichester (UK): John Wiley & Sons Ltd; 2021. p. 155-58.

28. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al, editors. *Cochrane Handbook for Systematic Reviews of Interventions* version 6.5 (updated August 2024) [Internet]. Cochrane; 2024. Available from: www.training.cochrane.org/handbook.
29. Jafari H, Van de Broek K, Plaghki L, Vlaeyen JW, Van den Bergh O, Van Diest I. Respiratory hypoalgesia? Breath-holding, but not respiratory phase modulates nociceptive flexion reflex and pain intensity. *Int J Psychophysiol* 2016; 101(1): 50-8.
30. Kimura Y, Ge HY, Zhang Y, Kimura M, Sumikura H, Arendt-Nielsen L. Evaluation of sympathetic vasoconstrictor response following nociceptive stimulation of latent myofascial trigger points in humans. *Acta Physiol (Oxf)* 2009; 196(4): 411-7.
31. Drummond PD. The effect of pain on changes in heart rate during the Valsalva manoeuvre. *Clin Auton Res* 2003; 13(5): 316-20.
32. Reyes del Paso GA, Montoro C, Muñoz Ladrón de Guevara C, Duschek S, Jennings JR. The effect of baroreceptor stimulation on pain perception depends on the elicitation of the reflex cardiovascular response: Evidence of the interplay between the two branches of the baroreceptor system. *Biol Psychol* 2014; 101: 82-90.
33. Alan SF. Blood Pressure: Baroreceptors. In: Squire LR, editor. *Encyclopedia of Neuroscience*. Oxford: Academic Press; 2010. p.259-64.
34. Shao P, Li H, Jiang J, Guan Y, Chen X, Wang Y. Role of vagus nerve stimulation in the treatment of chronic pain. *Neuroimmunomodulation* 2023; 30(1): 167-83.
35. Yuan H, Silberstein SD. Vagus nerve and vagus nerve stimulation, a comprehensive review: Part I. Headache 2016; 56(1): 71-8.
36. Shah JP, Thaker N, Heimur J, Aredo JV, Sikdar S, Gerber L. Myofascial trigger points then and now: a historical and scientific perspective. *PM&R*. 2015; 7(7): 746-61.
37. Hosseini SJ, Manzari ZS, Karkhah S, Heydari A. The effects of Valsalva manoeuvre on pain intensity and hemodynamic status during short peripheral cannula insertion in adults: a systematic review and meta-analysis. *J Vasc Access* 2024; 25(4): 1051-62.
38. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; 4: 863.
39. Salaffi F, Stancati A, Silvestri CA, Ciapetti A, Grassi W. Minimal clinically important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. *Eur J Pain* 2004; 8(4): 283-91.

Effect of task-oriented training on postural control in children with spastic diplegic cerebral palsy: a randomized controlled trial

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KEYWORDS

Task-oriented training,
Postural control,
Pediatric balance
scale, Cerebral palsy

ABSTRACT

Cerebral palsy is a leading cause of childhood-onset motor disability. Impaired postural control in children with cerebral palsy limits daily participation and increases lifelong reliance on caregivers. Therefore, interventions should prioritize improving postural control in these groups. This study aimed to compare the effect of task-oriented training (TOT) and conventional physiotherapy (CPT) on postural control in children with spastic diplegic cerebral palsy. A single-blinded randomized controlled trial study was conducted with 28 participants aged 3-15 years, randomly allocated into the TOT group and the CPT group. Both groups practiced for 60 minutes sessions, 3 times per week, for 6 weeks. Postural control was assessed using Pediatric Balance Scale at baseline, after 4th week, and 6th week of treatment. Data were analyzed using Friedman test for within-group comparisons across time points, while the Wilcoxon Signed-Rank test and the Mann-Whitney U test were used for within- and between- groups comparisons at each assessment period. Statistical significance was set at p -value < 0.05. Both groups showed significant improvement after 6 weeks of treatment; however, the TOT group demonstrated greater improvements (mean differences value of 6.85 points) compared to the CPT group (mean differences value of 4.36 points). These findings indicate that TOT significantly improves postural control in children with spastic diplegic cerebral palsy, yielding better outcomes than CPT.

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Introduction

Cerebral palsy (CP) is a leading cause of childhood-onset motor disability. Current evidence indicates that its birth prevalence is substantially higher in low-and middle-income countries, reaching up to 3.4 per 1000 live births, compared with approximately 1.6 per 1000 live births in high-income countries ⁽¹⁾. It is a non-progressive motor disorder that may be accompanied by impairments in vision, hearing, cognition, sensation, perception, communication, behavior, epilepsy, and secondary musculoskeletal problems. These impairments can result in lifelong limitations in daily activities and participation in social, educational, and community life. The prevailing type of CP is spastic type, classified anatomically into diplegia, hemiplegia and quadriplegia, with spastic diplegia being most ^(2,3).

Children with spastic diplegic CP is characterized by more motor impairment in the lower limbs than the upper limbs, with trunk weakness and limbs spasticity, resulting in delayed motor milestones, gait abnormalities, and impaired postural control. However, they generally have good cognitive function and are highly amenable to treatment among all types of CP ⁽³⁾. Deficits in functional balance, a key component of postural control, are common in children with CP due to their impaired postural control mechanism. As a results, children with CP require more focused attention to maintain their posture than typically developing peers. This, along with a fear of fall, reduces their ability to manage concurrent tasks and negatively affects their quality of life, often resulting in increased reliance on caregivers ⁽⁴⁻⁶⁾. Additionally, the long-term management of CP imposes substantial economic burdens on affected families and health systems ⁽⁷⁾.

Enhancing postural control should be focused as the main rehabilitation goal in CP⁽⁸⁾. Although conventional physiotherapy interventions such as active and passive exercises, stretching, progressive resistance exercise, trunk-targeted

training and balance training are widely used in children with CP, evidence for their effectiveness in improving postural control remains limited. Functional electrical stimulation, neurodevelopmental therapy, Biodex balance training, treadmill training, virtual reality and visual biofeedback, sensory integration therapy, and hippotherapy have shown potential benefits; however, many remain difficult to implement in routine clinical practice because they require specialized equipment, intensive resources, combined approaches, or lack of standardized treatment protocol⁽⁹⁾.

Task-oriented training is a top-down restorative intervention based on the motor control and modern motor learning theories. It promotes skill acquisition and neural plasticity through goal-directed, active, repetitive, task-specific practice and feedback improving functional mobility, postural control, and the quality of life in children with CP while considering fatigue and fall risk. Evidences suggest that the TOT addresses sensory-motor, social, emotional, and functional difficulties enhancing meaningful improvements within a relatively short training duration of approximately 14 to 25 hours. Moreover, TOT is a simple, time-efficient, cost-effectiveness training that requires minimal equipment and workforces⁽¹⁰⁻¹²⁾.

Evidence comparing task-oriented training (TOT) with conventional physiotherapy (CPT) remains inconclusive to enhance balance in children with CP due to heterogeneity in participants characteristics, outcome measures, intervention protocols, small sample sizes, and methodological variations across studies⁽¹³⁾. The present study specially focused on children with spastic diplegic cerebral palsy (Communication Function Classification System (CFCFS) as Level I-III, Gross Motor Function Classification System-Expanded and Revised version (GMFCS-E&R) as levels I-II, and a Modified Ashworth Scale (MAS) score of ≤ 2) and evaluated postural control using the Pediatric Balance Scale at three time points

following a standardized 6-week treatment protocol. Therefore, the aim of this study was to compare the effect of task-oriented training and conventional physiotherapy on postural control in children with spastic diplegic cerebral palsy.

Materials and methods

Research design and participants

A total of 28 children with spastic diplegic cerebral palsy were recruited from the Outpatient Department of Physiotherapy in the 550 Bedded Children Hospital, Mandalay and the School for Disabled Children, Mandalay. The sample size was calculated based on the difference between two independent means of Pediatric Balance Scale outcome data from the previous research⁽¹⁴⁾, with $\alpha=0.05$, and power= 0.80. The study was designed as a single-blinded randomized controlled trial. Participants were recruited using convenience sampling and then allocated equally to either the experimental group undergoing TOT, or the conventional group receiving CPT through block randomization. The study was conducted in accordance with the guidelines of the Declaration of Helsinki and ethical approval (approval No. IRB/UMTM-2024-004) was obtained from the Institutional Review Board of the University of Medical Technology, Mandalay. The study was prospectively registered with Myanmar Health Research Registry (Registration No. PLRID-04361.V2). Inclusion criteria were children of both sexes aged between 3 and 15 years with spastic diplegic cerebral palsy, classified as Communication Function Classification System (CFCS) as Level I-III and Gross Motor Function Classification System-Expanded and Revised version (GMFCS-E&R) as levels I or II, with a Modified Ashworth Scale (MAS) score of ≤ 2 ^(15,16,3). Children with spastic diplegic cerebral palsy who had presented with specific medical or orthopedic conditions such as visual deficits, contracture and deformity that precluded exercising were excluded from the study. Written informed consent form was signed by caregivers and assent form was obtained from their children.

Treatment procedure

The study was conducted over 6 weeks, with 18 sessions (3 sessions per week), each lasting about 60 minutes in children with spastic diplegic cerebral palsy. Assessments were performed at week 0 (before treatments), week 4, and week 6 after treatments using Pediatric Balance Scale (PBS) for postural control by an independent blinded assessor. Both groups received 10 minutes of preparatory exercises (hip adductors stretching and half squat to standing exercise) to improve flexibility and optimize participant's readiness for the subsequent trainings, followed by 50 minutes main exercises (TOT or CPT)^(14,17,18). All participants in both groups were closely supervised by the researcher and received the same protocol, and treatment duration to ensure consistency of training intensity across participants and minimize potential fatigue and fall risks during the training. Details of the treatment protocols in each group are as follows.

Treatment protocols for the experimental group

The experimental group received seven TOT activities designed to mimic functional activities of lower limb muscles that resembled everyday tasks: 1) maintaining a standing position; 2) performing a single leg stance while holding a chair; 3) standing balance activities such as reaching for a toy in different directions; 4) sit to stand from a chair without using their arms; 5) standing up from a half kneeling position; 6) kicking a ball; 7) stepping up onto a stool. The program was adapted from earlier TOT protocols^(14,17,18) to suit children with similar functional levels as the activities were based on the patients' functional problems such as impaired postural control and reduced standing balance and treatment goal. The exercises were performed in a play-based manner, which helped maintain the children's interest and active participation enhancing positive effects on muscle strength, weight shifting, postural control, and functional mobility. Each of these exercises was performed

in a fixed order for 3,6,9,3,6,4 and 8 minutes, respectively, with 1-2 minutes of rest between activities, resulting in an approximately 50-minute session. Progression was individualized based on each child's improvement and included reducing base of support, without holding support, increasing task difficulty, repetitions, holding time, and the distance reached^(14,18).

Treatment protocols for the conventional group

The conventional group received CPT including passive stretching of hamstring, quadriceps, and calf muscles performed for 5 repetitions per side with a 15- to 30-second hold. Strengthening exercises included bridging (10 repetitions), lower trunk rotation (5 repetitions per side), and quadruped (5 repetitions per side), and heel rise (10 repetitions), with each repetition held for 15 to 30 seconds. The CPT program reflected routine clinical practice commonly implemented in the study setting and was based on the previous studies^(14,17,18) to address muscle tightness, improve joint range of motion, lower limb strength, postural alignment, and functional balance which are essential components for improving postural control in children with CP.

Data collection

Data collection is presented in the CONSORT flow diagram of participants (Figure 1). The assessments for postural control using Pediatric Balance Scale (PBS) were carried out at week 0, 4 and 6 by an experienced physiotherapist who worked with pediatric patients for nearly 11 years. The PBS is a reliable and valid measure of functional balance in school-aged children with mild to moderate disabilities. It comprises 14 items scored from 0 to 4 (maximum score=56), with higher scores reflecting better balance. It takes approximately 20 minutes to administer and allows practice trials. It demonstrates excellent reliability (test-retest Intraclass Correlation Coefficient [ICC] = 0.998; interrater ICC = 0.997⁽⁴⁾; intra-rater ICCs = 0.997⁽¹⁹⁾) and strong concurrent validity with the Functional Reach Test ($r = 0.692$; $p < 0.001$)⁽²⁰⁾. It also shows moderate responsiveness, with minimal detectable change (MDC) values of 0.79, 0.96, and 1.59, and the minimal clinically important differences (MCID) ranges of 1.47-2.92, 2.23-2.92, and 3.66-5.83 for the PBS-static, PBS-dynamic, and PBS-total scores, respectively⁽⁵⁾. The data were then systematically recorded into the pro forma for data analysis.

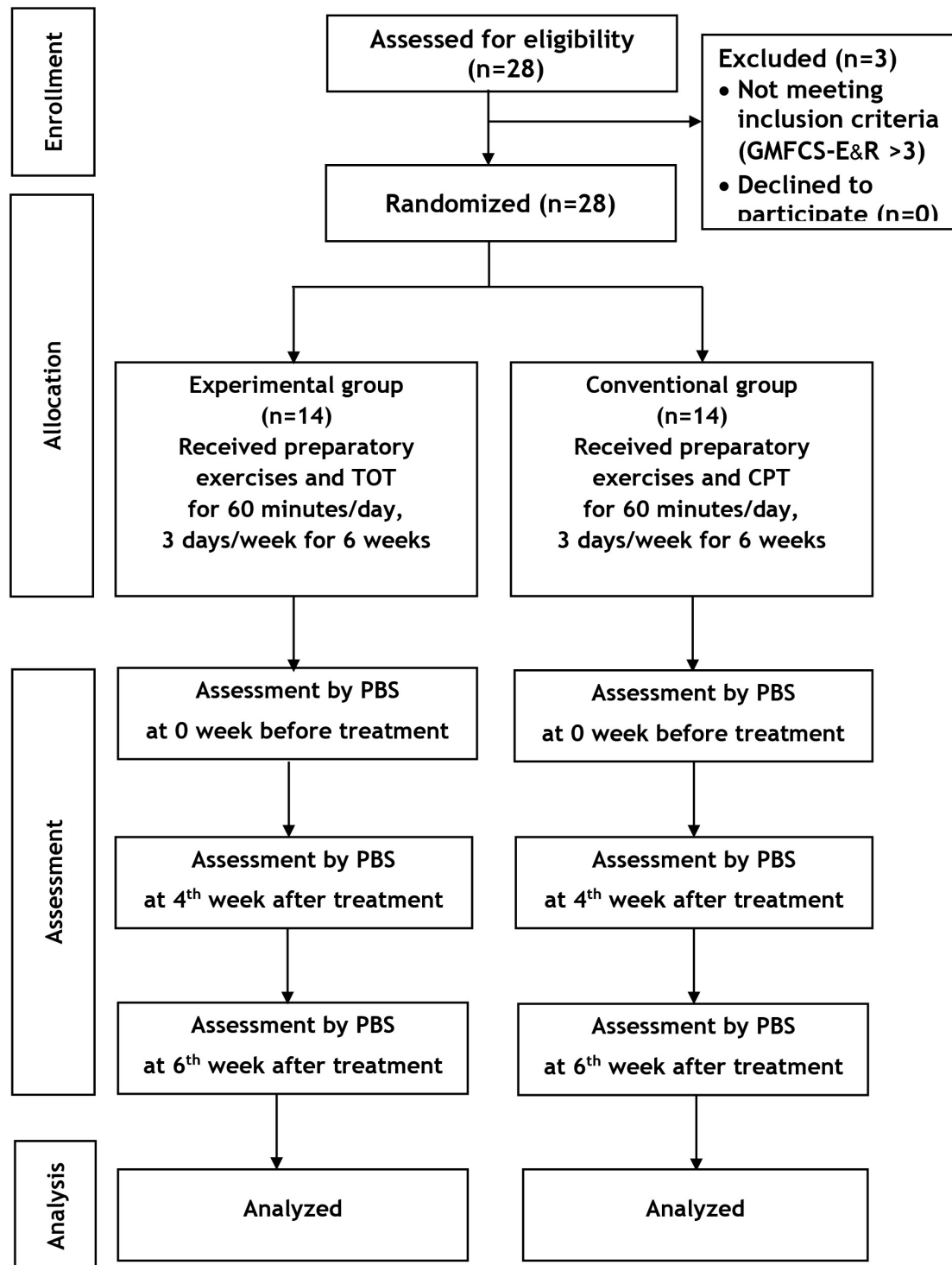


Figure 1 The CONSORT flow diagram of participants
TOT, Task-oriented training; CPT, Conventional physiotherapy; PBS, Pediatric Balance Scale

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 23. Demographic and clinical characteristics, and PBS scores were summarized using descriptive statistics (mean $\pm$ standard deviation, frequency and percentage). Independent Samples *t*-test was used for continuous variables and Chi-square test for categorical variables. The Shapiro-Wilk test showed that PBS scores were not normally distributed. Therefore, non-parametric statistical methods were employed to analyze PBS outcomes. The Friedman test was performed for within group comparison across assessment time points while the Wilcoxon Signed-Rank test and Mann-Whitney U test were used for within and between group comparisons

at each time point. The significant level was set at p -value < 0.05 .

Results

All participants successfully completed the training without dropouts or adverse effects, possibly due to their active engagement, caregiver cooperation, scheduled rest periods, and close therapist supervision, which ensured safe training despite potential fatigue, or fall risks.

The demographic and clinical characteristics of the participants are shown in Table 1. There were no significant differences between the groups in any of the demographic variables.

Table 1 Demographics and clinical characteristics of the participants.

Characteristics	TOT group (n=14)	CPT group (n=14)	<i>p</i> -value
Age group (year); n (%)			
3-7	4 (28.6%)	6 (42.9%)	0.695
8-15	10 (71.4%)	8 (57.1%)	
Age (year); (mean $\pm$ SD)	10.93 $\pm$ 3.69	9.79 $\pm$ 3.49	0.407
Sex			
Male	6 (42.9%)	6 (42.9%)	1.000
Female	8 (57.1%)	8 (57.1%)	
CFCS level I	14 (100%)	14 (100%)	
GMFCS-E&R level II	14 (100%)	14 (100%)	
MAS Score			
1	12 (85.7%)	10 (71.4%)	0.648
1 +	2 (14.3%)	4 (28.6%)	

Note: p -value < 0.05 is statistical significance. TOT, Task-oriented training; CPT, Conventional physiotherapy; CFCS, Communication Function Classification System; GMFCS-E&R, Gross Motor Function Classification System-Expanded and Revised version; MAS, Modified Ashworth Scale.

Although both groups demonstrated improvements in PBS item scores after 6 weeks of treatment, the TOT group showed greater improvements from baseline to week 6 than the CPT group, particularly in several challenging

balance tasks. A higher proportion of participants in the TOT group achieved improved PBS scores in item 8 (standing with one foot in front), item 9 (standing on one foot), item 10 (turning 360 degrees), items 11 (turning to look behind), item

13 (placing alternate foot on stool) and item 14 (reaching forward with outstretched arm), indicating superior improvement in postural control.

The comparisons of PBS scores within- and between-group are shown in Table 2. Within-group analysis revealed significant improvement in PBS scores after 6th week of treatment in both groups (p -value < 0.001) although no significant change

was observed after 4th week in either group compared with baseline score (p -value = 1.000). Between-group analysis showed no significant difference in PBS scores at baseline (p = 0.299) or week 4 (p -value = 0.299). However, a statistically significant difference was emerged at week 6 (p -value= 0.017), with the TOT group demonstrating greater improvement.

Table 2 Comparisons of PBS scores within- and between- group

PBS	0 week	4 th week	6 th week	^a p -value	Mean difference between 0 week and 6 th week
	mean $\pm$ SD; median (IQR)	mean $\pm$ SD; median (IQR)	mean $\pm$ SD; median (IQR)		
TOT group (n=14)	41.79 $\pm$ 2.94; 41.00 (39.00 - 45.00)	41.79 $\pm$ 2.94; 41.00 (39.00 - 45.00)	48.64 $\pm$ 4.07; 48.00 (45.00 - 52.25)	* < 0.001	6.85
CPT group (n=14)	40.64 $\pm$ 2.02; 39.50 (39.00 - 43.00)	40.64 $\pm$ 2.02; 39.50 (39.00 - 43.00)	45.00 $\pm$ 1.57; 44.50 (44.00 - 46.25)	* < 0.001	4.36
^b p -value	0.299	0.299	*0.017		

Note: * p -value<0.05, statistical significance; ^a p -value: within- group comparison; ^b p -value: between- group; PBS, Pediatric Balance Scale; TOT, Task-oriented training; CPT, Conventional physiotherapy.

Discussion

This study investigated the effect of a 6-week TOT on postural control in children with spastic diplegic CP, using PBS. Baseline PBS scores did not differ within and between two groups, and participants did not receive additional treatments outside the study protocol during the study period. Therefore, the changes observed during this study could be attributed substantially to the effects of the exercise programs rather than external factors. Both groups showed improvements in PBS scores from baseline to week 6; however, greater improvement was observed in the TOT group than in the CPT group. Therefore, TOT may be more effective than CPT in enhancing postural control.

At baseline, all participants in this study struggled most with specific items on PBS requiring advanced postural control and reduced base of support in items 8 (standing with one foot in

front), item 9 (standing on one foot), item 13 (placing alternate foot on stool), item 10 (turning 360 degrees), item 11 (turning to look behind) and item 14 (reaching forward with outstretched arm). These findings aligned with the results of Franjoine et al.⁽²¹⁾, who also similarly reported reduced performance in these challenging items. Therefore, no participant got the highest score of 4 on items 8, 9, 11, 13 and 14, with all scoring no higher than 1 on item 9. Conversely, all attained the highest scores on items 1 through 5, indicating these items were less challenging and potentially subject to ceiling effects, which reduced their sensitivity in detecting changes resulting from the experimental manipulation.

After 4th week of treatment, some participants from both groups demonstrated functional gains such as longer holding time in item 9, more efficient completion of 8 steps in item 13, and greater

forward reach in item 14, but these gains were insufficient to change PBS scores. Therefore, no significant within-group changes were noted between 0 week and 4th week. However, extremely significant improvements were observed after 6th week of treatment in both groups (p -value < 0.001), while items 1 through 5, which had already reached the highest score prior to treatment, remained unchanged due to ceiling effects.

The lack of significant PBS score changes either within-group nor between-group after 4th week of treatment may be explained due to the scoring structure of PBS, that time alone does not necessarily determine progression, therefore, suggesting that combining PBS with timed up and go test may better capture progress.

After 6th week of treatment, TOT group showed mean improvement in PBS scores (mean difference of 6.85) exceeded the upper range of PBS minimal clinically important differences (MCID), indicating clinically meaningful functional improvement, whereas CPT group (4.36) falls within the MCID range but does not exceed it. There were MCID ranges of 3.66-5.83 for PBS total scores⁽⁵⁾.

In this study, both TOT and CPT treatments were safe and well tolerated, with no adverse events or dropouts. However, the TOT group showed greater improvement, consistently outperforming the CPT group on PBS items 8 through 14. Effective neural plasticity, crucial for rehabilitation, is achieved through task specific training, exemplified by the TOT, which outperforms generic approaches⁽¹²⁾. The superior improvements in TOT group could be attributed to its foundation in motor control and motor learning theory, as it engaged children in meaningful, goal directed, tasks specific activities with repetitive practice, promoting neuroplasticity, improving proprioception, increasing weight bearing ability and enhancing postural control stability⁽¹⁰⁾. Conventional physiotherapy improved PBS scores through stretching and strengthening with repetitions, but its exercises were less context specific,

which may have limited the transfer of therapeutic gains to diverse real-life tasks.

These results aligned with the research findings of the previous studies and systematic reviews^(14,17,18,22-24), which reported greater improvements in postural control following TOT compared with CPT in children with spastic diplegic cerebral palsy. However, variations in sample size, treatment duration, CP subtypes, GMFCS levels, exercise protocols, and outcome measures may explain differences in the magnitude of improvement across studies. Compared with previous studies, this study applied a clearly defined intervention frequency and specific participant characteristics. Unlike a previous study, published in 2020 reporting the efficacy of TOT after 20 sessions over 4 weeks⁽¹⁸⁾, no significant changes were observed at week 4 in either group of this study, possibly because participants trained only 12 sessions within the same period. These findings suggest that long duration TOT may be necessary to achieve measurable improvement in postural control in children with spastic diplegic CP.

The findings suggest that both TOT and CPT can be incorporated into clinical rehabilitation programs to enhance functional independence and reduce caregiver burden. The TOT, however, appears to be feasible and effective 6-week intervention, producing greater improvement in postural control in children with spastic diplegic cerebral palsy. However, generalizability was limited by inclusion of specific sample, attentional resources, short duration, lack of follow-up and use of PBS alone. Future studies should include diverse CP populations, attentional resources, longer follow-up, and additional functional balance measures such as the timed up and go test to more precisely determine the effect of TOT.

Conclusions

The study results demonstrated that a 6-week task-oriented training was an effective and feasible program to improve postural control

in children with spastic diplegic cerebral palsy, yielding better outcomes than conventional physiotherapy.

Take home messages

The six-week task-oriented training effectively improve postural control in children with spastic diplegic cerebral palsy. Incorporating this program into a standard program can improve postural control enhancing quality of life and reducing family burdens.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

Thandar Aung: Conceptualization, methodology, data collection, formal analysis, writing-original draft.

Nilar Aung: Conceptualization, methodology, formal analysis, writing-review & editing.

Thant Thant Aung: Conceptualization, methodology, formal analysis, writing-review & editing.

Kyaw Myo: Conceptualization, methodology.
May Myanmar Khant: Methodology.

Data availability

Data available on request due to privacy/ethical restrictions.

References

1. McIntyre S, Goldsmith S, Webb A, Ehlinger V, Hollung SJ, McConnell K, et al. Global prevalence of cerebral palsy: A systematic analysis. *Dev Med Child Neurol* 2022; 64(12): 1494-1506. <https://doi.org/10.1111/dmcn.15346>.
2. Burgess A, Sakzewski L, Sakzewski L, Whittingham K, Wotherspoon J, Chatfield MD, et al. Development of social functioning in children with cerebral palsy: A longitudinal study. *Dev Med Child Neurol* 2023; 65(5): 674-82.
3. Berker N, Yalcin S. *The Help Guide to Cerebral Palsy*. 2nd Edition. Merrill Corporation: Washinton; 2010: pp 12-104.
4. Franjoine MR, Gunther JS, Taylor MJ. Pediatric balance scale: A modified version of the berg balance scale for the school-age child with mild to moderate motor impairment. *Pediatr Phys Ther* 2003; 15(2): 114-28.
5. Chen CL, Shen IH, Chen CY, Wuc CY, Liu WY, Chung CY. Validity, responsiveness, minimal detectable change, and minimal clinically important change of pediatric balance scale in children with cerebral palsy. *Res Dev Disabil* 2013; 34(3): 916-22.
6. Towns M, Lindsay S, Arbour-Nicitopoulos K, Mansfield A, Wright FV. Balance confidence and physical activity participation of independently ambulatory youth with cerebral palsy: An exploration of youths' and parents' perspectives. *Disabil Rehabil* 2020; doi: 10.1080/09638288.2020.1830191.

7. Ismail A, Sk Abd Razak R, Suddin LS, Mahmud A, Kamaralzaman S, Yusri G. The economic burden and determinant factors of parents/ caregivers of children with cerebral palsy in Malaysia: A mixed methods study. *Int J Environ Res Public Health* 2022; 19: 475.
8. de Araújo PA, Starling JMP, Oliveirac VC, Gontijoa APB, Mancini MC. Combining balance-training interventions with other active interventions may enhance effects on postural control in children and adolescents with cerebral palsy: A systematic review and meta-analysis. *Braz J Physl Ther* 2019; 24(4): 295-305.
9. Dewar R, Love S, Johnston LM. Exercise interventions improve postural control in children with cerebral palsy: A systematic review. *Dev Med Child Neurol* 2014; 57: 504-20.
10. Choi Y, Jung H. A Commentary on task-oriented interventions in the functional mobility and postural control of children with cerebral palsy. *Int J Neurorehabilitation* 2018; 5(2): 314.
11. Jackman M, Lannin N, Galea C, Sakzewski L, Miller L, Novak I. What is the threshold dose of upper limb training for children with cerebral palsy to improve function? A systematic review. *Aust Occup Ther J.* 2020; 67:269- 80. doi: 10.1111/1440-1630.12666.
12. Rossi F, Gianola S, Corvetti L. Regulation of intrinsic neuronal properties for axon growth and regeneration. *Prog Neurobiol* 2007; 81: 1-28.
13. Karnadipa T, Xin W, Pickering D, Carrier J. Effectiveness of task-specific training for improving balance performance in children with cerebral palsy (CP): A narrative systematic review. *Physiother Q* 2024; 32(1): 15-24.
14. Shaju. Study on efficacy of task-oriented training on mobility and balance among spastic diplegic cerebral palsy children. *J Neurol Neurosurg* 2016; 1(3): 555562.
15. Hidecker MJC, Paneth N, Rosenbaum PL, Kent RD, Lillie J, Eulenberg JB, et al. Developing and validating the communication function classification system for individuals with cerebral palsy. *Dev Med Child Neurol.* 2011; 53(8): 704-710. doi:10.1111/j.1469-8749.2011.03996.x.
16. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content Validity of the Expanded and Revised Gross Motor Function Classification System. *Dev. Med. Child Neurol.* 2008; 50: 744-750. doi:10.1111/j.1469-8749.2008.03089.x.
17. Kim JH, Choi YE. The effect of task-oriented training on mobility function, postural stability in children with cerebral palsy. *J Korean Soc Phys Med* 2017; 12(3): 79-84.
18. Madhumathi K, Selvam PS, Megala K. Efficacy of task-oriented training on balance and gross motor function in spastic diplegic cerebral palsy children. *Paripex - Indian J Res* 2020; 9(4). doi: 10.36106/paripex.
19. Gan SM, Tung LC, Tang YH, Wang CH. Psychometric properties of functional balance assessment in children with cerebral palsy. *Neurorehabil Neural Repair* 2008; 22(6): 745-53.
20. Erden A, Arslan EA, Dündar B, Topbaş M, Cavlak U. Reliability and validity of Turkish version of pediatric balance scale. *Acta Neurol Belg* 2020; doi: 10.1007/s13760-020-01302-9.
21. Franjoine MR, Darr N, Young B, McCoy SW and Fiss AL. Examination of the effects of age, sex, and motor ability level on balance capabilities in children with cerebral palsy GMFCS levels I, II, III and typical development using the Pediatric Balance Scale. *Dev Neurorehabil* 2021; doi: 10.1080/17518423.2021.1943033.
22. Sah AK, Balaji GK, Agraphara S. Effects of task-oriented activities based on neurodevelopmental therapy principles on trunk control, balance, and gross motor function in children with spastic diplegic

- cerebral palsy. *J Pediatr Neurosci* 2019; 14: 120-6.
23. Hotari SP. Effect of therapist-delivered task-oriented training on functional mobility and balance in children with cerebral palsy: A systematic review and meta-analysis [Master's thesis]. Tromsø: UiT The Arctic University of Norway; 2022.
24. Zai W, Xu N, Wu W, Wang Y, Wang R. Effect of task-oriented training on gross motor function, balance and activities of daily living in children with cerebral palsy: A systematic review and meta-analysis. *Medicine (Baltimore)* 2022; 101: 44.

Effects of exercise programs in individuals with severe obesity scheduled for undergoing bariatric surgery: a quasi-experimental study

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KEYWORDS

Physical fitness;
Obese; Surgical
treatment;
Exercise;
Non-invasive
treatment.

ABSTRACT

Rapid weight reduction and improved physical fitness are essential for individuals with severe obesity who undergo bariatric surgery in helping surgeons to operate with fewer complications. However, there is limited evidence regarding the structure exercise programs combined with dietary control in these individuals. Therefore, this study proposed exercise programs, and assessed the feasibility and effectiveness of a short-duration exercise and dietary control program on weight reduction and physical fitness in 10 individuals with severe obesity preparing for bariatric surgery. Participants who were diagnosed with severe obesity (body mass index 54.4 ± 10.7 kg/m²) and were scheduled for bariatric surgery involved in the 2-week exercise program with the outcome measurement before and after the program. The exercise program consisted of stretching, weight training, and cardiovascular exercise, 60-90 minutes per session for a total of 10 sessions with a physical therapist closely supervising, encouraging, and monitoring the sessions to ensure safety. Concurrently, all participants followed a calorie-restricted diet of 500-800 kcal/day. The findings were compared using the Wilcoxon Signed Ranks Test. The results demonstrated the significant bodyweight reduction (-5.84 ± 2.09 kg, $-4 \pm 1.3\%$) with physical fitness improvement, including handgrip strength (3.50 kg), the five times sit-to-stand test (-2.48 s), the chair sit-and-reach test (7.50 cm), and the 1-minute step test (8.5 repetitions) ($p < 0.01$). The findings suggest the clinical benefit of 2-week exercise programs in individuals with severe obesity scheduled for undergoing bariatric surgery.

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Introduction

Obesity, body mass index (BMI) ≥ 30.0 kg/m², is a chronic metabolic disease and a major public health challenge in Thailand and worldwide⁽¹⁾. According to the World Health Organization (WHO) criteria, 19% of Thai population were overweight (BMI 25.0-29.9 kg/m²), 4% were class I obesity (BMI 30.0-34.9 kg/m²), 0.8% were class II obesity (BMI 35.0-39.9 kg/m²), and 0.1% were class III obesity (BMI ≥ 40.0 kg/m²)⁽¹⁻²⁾. The obesity and related comorbidities, such as type 2 diabetes, hypertension, dyslipidemia, and obstructive sleep apnea syndrome are considered as one of the medical challenges of the 21st century⁽³⁻⁶⁾. These medical consequences attribute to the reduction in exercise tolerance, daily mobility, and quality of life of the individuals⁽⁷⁾.

Bariatric surgery is one of the most effective treatment options, producing substantial weight loss and improving obesity-related comorbidities, and long-term health outcomes⁽⁸⁻⁹⁾. The surgical protocol is suggested for individuals with BMI of 32.5 kg/m² and over, who have co-morbidities that fail to achieve adequate control by full effort of any other methods; or those with a BMI of 37.5 kg/m² or more without co-morbidities⁽¹⁰⁾. Nonetheless, bariatric care does not end with surgery alone. Contemporary treatment pathways are multidisciplinary and may include dietary management, psychological support, medical optimization, and structured physical therapy before and after surgery⁽¹¹⁻¹²⁾.

Prior to bariatric surgery, the individuals are recommended to reduce their bodyweight by 5% to 10% within 1 to 2 weeks to optimize surgical outcomes as most people with obesity present with hepatomegaly (fatty liver), in which the enlarged liver can obscure the surgical area⁽¹³⁻¹⁴⁾. Rapid preoperative weight reduction would help to decrease liver size, thereby facilitating the surgical procedure and minimizing complications⁽¹⁰⁾.

Among many variables, poor physical fitness is a key factor in the vicious obesity cycle and

morbidity of obese individuals⁽¹⁵⁾. In addition, the physical appearance due to excess skin, soft tissue laxity, loss of body firmness following rapid weight loss are major concerns affecting self-image, confidence in daily life, and physical fitness of the individuals⁽¹⁶⁾. To the best of the researchers' knowledge, there is limited evidence regarding the structure exercise programs combined with dietary control in individuals with severe obesity. Therefore, this study proposed exercise programs and preliminarily assessed the feasibility and effectiveness of exercise program combined with dietary control on physical fitness in individuals with severe obesity who were preparing to undergo bariatric surgery. The findings may provide clinical guideline for preoperative programs among individuals preparation for bariatric surgery.

Materials and methods

Study design and participants

This quasi-experimental design was conducted in individuals with severe obesity (BMI ≥ 40 kg/m²) without co-morbidities affecting the participation in the exercise program as diagnosed by a physician and scheduled to undergo bariatric surgery during October 2025 to January 2026. The additional inclusion criteria included the age of 18 to 65 years old, both male and female. Participants who attended less than 80% of all appointments prior to the surgery were excluded from the study⁽¹⁰⁾. The number of sample size was estimated from a previous study that assessed effects of perioperative exercise therapy in bariatric surgery in 10 participants/group⁽¹⁷⁾. The research protocols of this study were approved by the ethic committees of human research, Khon Kaen University (HE691150).

Research protocol

Upon the consult by a surgeon for preoperative rehabilitation programs, the individuals were assessed for their eligibility to the criteria of the study. The eligible participants were interviewed and assessed for their demographic and contraindication of the exercise program. Then they were

assessed for the baseline outcomes of the study, including age, BMI, comorbidities, the handgrip (HG) strength test, five times sit-to-stand test (FTSST), chair sit and reach test, and 1-minute step test (1-MST) to reflect muscle strength of the upper and lower extremities, flexibility, and endurance. Then, they were involved in exercise programs, i.e., often called prehabilitation, over two weeks with outcome assessment thereafter. Details of the training programs and outcome measured are explained below.

Prehabilitation program

A prehabilitation program was designed to improve physical fitness of the participants prior to undergoing Sleeve Gastrectomy, i.e., a primary, irreversible bariatric surgical procedure involving the anatomical reconstruction of the stomach⁽¹⁸⁾. The program consists of stretching exercises to promote muscular flexibility for the trunk and extremities (5-10 minutes), resistant exercises (15-20 minutes) to improve muscle strength and cardiovascular endurance (40-60 minutes) (Table 1 and Figure 1). As the program was conducted in the hospital, the exercise sequences for stretching and resistant training were executed according to the availability of the equipment and setting. An experienced physical therapist facilitated the participants to achieve the criteria as indicated in Table 1. Participants were monitored their vital signs continuously throughout the exercise program to prevent any adverse events, such as excessive dyspnea, dizziness, chest pain, palpitations, musculoskeletal pain, and abnormal cardiovascular responses, as well as hypoglycemia during exercise due to nutrition restriction. They could take a period of sufficient rest as needed or until the vital signs returned to the baseline levels. Each session lasted approximately 60-90 minutes/session, 5 sessions/week, over 2 weeks for a total of 10 sessions/participant.

Dietary control program

The dietary control for the participants was under the supervision of a registered nutritionist, with the aim of weight reduction and increased

body composition. Daily energy intake was prescribed as a caloric deficit of approximately 500-800 kcal/day relative to each individual's total energy requirement. Total energy needs were estimated based on basal metabolic rate (BMR) in combination with physical activity level^(10,19).

Outcome measurements

Before and after the training program, participants were assessed for the outcomes of the study, including bodyweight, the HG strength test, FTSST, chair sit and reach test, and 1-MST. Details of the measurements are as follows.

Bodyweight and body mass index: Bodyweight is an important preoperative indicator. Individuals are commonly recommended to achieve a 5%-10% reduction in bodyweight before surgery. Then, bodyweight and BMI were assessed before and after completion of the 2-week exercise program.

Handgrip strength test: The test was measured using a Takei Hand Grip Dynamometer (Analogue; Takei Scientific Instruments Co., Ltd., Niigata, Japan). Before testing, the dynamometer handle was adjusted to fit each participant's hand size. Participants stood in an upright position with their feet shoulder-width apart. The tested arm was held slightly abducted away from the trunk, with the elbow fully extended and the wrist in a neutral position. Participants were instructed to squeeze the dynamometer with maximal effort for approximately 3-5 seconds while maintaining the testing position and avoiding compensatory body movements. Two trials were performed using the dominant hand, with a 30-second rest interval between trials. The maximum value was recorded⁽²⁰⁻²¹⁾.

Five times sit-to-stand test: The FTSST evaluated lower limb muscle strength and balance ability while changing postures of sit-to-stand transitions. FTSST demonstrated good inter-rater reliability (ICC = 0.880) and excellent intra-rater reliability (ICC = 0.902)⁽²²⁾. Participants were seated on a standard chair without armrests, with their feet placing flat on the floor. They were

instructed to stand up completely and sit down for five consecutive times as quickly and safely as possible. The test was performed twice with a 1-minute rest interval between trials. The shortest completion time, recorded in seconds, was used for statistical analysis⁽²³⁾.

Chair sit and reach test: This test assessed flexibility of the hamstring and lower back muscles. Participants sat on the edge of a chair. Non-dominance foot remained flat on the floor, while the dominance leg was extended forward with a straight knee, the heel on the floor, and the ankle bent at 90 degrees. The participants crossed both hands and evened their middle fingers. Then, they reached forward as far as possible toward their toes. If the participants could not reach their toes, the distance between the fingertips and toes was recoded as a negative score. In contrast, if the participant's fingertips overlapped their toes, their overlapping distance was recorded positively^(21,24). Participants performed twice and the best score was recorded.

1-minute step test: The submaximal exercise test used to assess functional exercise capacity and cardiorespiratory fitness. A similar step test has demonstrated good reliability and validity for evaluating functional exercise capacity in clinical populations, while the 1-MST has been reported to be feasible and safe for clinical use⁽²⁵⁾. Participants were instructed to march in place, raising each knee to a predetermined height set at the midpoint between the patella and the anterior superior iliac spine, continuously as many times as possible in a minute. The data were counted every time the right knee reaching the target height, and the total number of completed steps after one minute was recorded.

During and after completion of the tests, participants were monitored for their vital signs, the Borg Rating of Perceived Exertion Scale (RPE)⁽²⁶⁾, and any abnormal symptoms, such as dizziness, excessive fatigue, or chest pain. If any adverse symptoms occurred, the test was terminated immediately according to submaximal exercise safety guidelines⁽²⁷⁾.

Statistical analysis

Descriptive statistics were used to explain demographics of the participants and findings of the study. As the data were non-normally distributed, the findings within the groups (before and after training) were compared using the Wilcoxon Signed Ranks Test. The level of statistical significance was set at p -value < 0.05.

Results

A total of 10 participants were included in this study, with the age range between 19 to 39 years old, and the maximum BMI of 79.92 kg/m², indicating severe obesity. Obstructive sleep apnea was the most common comorbidity found in the participants ($n = 9$, 90%), and each of them had 1 to 3 comorbidities (Table 2).

All participants attended 100% of all appointments with no adverse event during participation in this study. After the two-week program, participants demonstrated significant reduction in their bodyweight and BMI (p -value < 0.001) with the average change of their bodyweight of $4.0 \pm 1.3\%$ (range 2.4% to 6.9%). In addition, the HG strength test, FTSST, chair sit and reach test, and 1-MST were significantly improved after 10 sessions exercise and dietary control (p -value < 0.01) (Table 3).

Table 1 Prehabilitation exercise prescription for the participants

Types of exercise	Details of exercises	Duration/Intensity/Repetition
Stretching exercises	- Trunk - Upper extremities - Lower extremities	5-10 minutes
Resistant exercises	Lying position - Abdominal curl-up - Back extension - Supine stability ball hamstring curl - Supine stability ball bridge with abdominal bracing - Front raise - Lateral raise Sitting - Rear shoulder raise - Biceps curl - Triceps extension - Knee extension - Sit to stand Standing - Hip flexion - Hip extension - Hip abduction - Hip adduction - Calf raises - Squat	- Day 1-3: 20 repetitions - Day 4-10: 30 repetitions (Moderate intensity or RPE 12-13)
Cardiovascular endurance exercise	- Stationary cycling (Recumbent bike) - Incline walking with prefer speed (standard slope in hospital)	20-30 minutes (50-70 RPM) 20-30 minutes (RPE 12-13)

Note: RPE , Rating of Perceived Exertion; RPM, Revolutions per minute



(a) Stretching exercise

Figure 1 Training protocols of the participants



Figure 1 Training protocols of the participants (Cont.)

Table 2 Baseline characteristics of participants (n = 10)

Variable	Findings
Demographic characteristics	
Age (years) ^a	31.2 ± 6.9
Sex; Male: n (%)	5 (50.0)
Comorbidities, n (%)	
Obstructive sleep apnea	9 (90.0)
Dyslipidemia	6 (60.0)
Hypertension	4 (40.0)
Diabetes mellitus	2 (20.0)
Other comorbidities	4 (40.0)

Note: ^a Data are presented as mean ± SD.

Table 3 Pre- and post-test outcomes of the participants (n = 10)

Variable	Median (Q1, Q3)		p-value ^b
	Pre- test	Post-test	
Weight (kg)	143.0 (131.2, 152.5)	138.4 (123.9, 154.3)	0.005*
Body mass index (kg/m ²)	53.1 (49.5, 57.0)	50.2 (47.5, 54.6)	0.005*
Five times sit-to-stand test (s)	9.4 (8.9, 12.1)	6.9 (5.4, 8.1)	0.005*
Hand grip strength test (kg)	32.0 (23.8, 40.5)	35.5 (29.1, 45.1)	0.005*
Chair sit and reach test (cm)	2.5 (-4.8, 5.5)	10.0 (1.8, 12.0)	0.008*
1-Minute step test (times)	46.0 (35.8, 54.0)	53.5 (51.0, 66.0)	0.005*

Note: The data were presented using Median (Q1, Q3). The pre- and post-test data were compared using the Wilcoxon Signed Ranks Test. Superscripts (*) indicated the data with significant differences.

Discussion

This study proposed exercise programs, and assessed the feasibility and effectiveness of exercise program combined with dietary control on physical fitness in 10 participants with severe obesity who prepared to undergo bariatric surgery. The results supported the feasibility and clinical contribution of a short duration (10 sessions) on weight and BMI reduction with increased physical fitness of the participants (Table 3).

The exercise program of this study consisted of stretching exercise, resistance training (trunk, upper and lower extremities), and endurance training in combination with dietary control with the aim to reduce the bodyweight and improve physical fitness of the participants. The positive effects suggested the benefit of a short duration intervention that facilitated meaningful physiological adaptations, particularly in the neuromuscular and cardiovascular systems of

participants with severe obesity⁽²⁹⁾. These adaptations were the characteristic of early-phase exercise, driven by neural mechanisms. A previous study also reported that the improved preoperative physical fitness was associated with a reduced risk of postoperative complications and improved recovery outcomes⁽²⁸⁾. However, these effects were not assessed in this study.

The bodyweight loss had been shown to reduce hepatic steatosis, decrease liver size, and improve surgical safety⁽³⁰⁾. Weight loss additionally decreased mechanical load on the musculoskeletal system, leading to improved movement efficiency⁽³¹⁾. However, the bodyweight loss of approximately 4% in this study did not reach the recommended target of 5-10% of initial body weight, as suggested by clinical practice guidelines for obesity management⁽¹⁰⁾. This may be due to the short duration of the intervention. A previous study applied 12-week training with cardiovascular and resistance exercise to change approximately 5% of their bodyweight⁽³²⁾.

Apart from exercise program, this study also incorporated the dietary control with caloric deficit of approximately 500-800 kcal/day. The findings are consistent with the principle of energy balance that is energy intake below energy expenditure, leading to a reduction in bodyweight and changes in body composition⁽³³⁾. The rapid weight loss observed during the early phase of the intervention was likely attributable to the negative energy balance created by caloric restriction and daily exercise, together with early depletion of glycogen stores and the associated loss of body water⁽³⁴⁾. The findings suggest the clinical benefit of multidisciplinary intervention on bodyweight and BMI reduction within a short period. Previous studies also reported that combined dietary and exercise interventions were more effective than either approach alone in promoting weight loss and improving body composition⁽¹⁹⁾. Jakicic et al⁽³¹⁾ also suggested that weight loss in individuals with obesity associated with significant improvements in physical function and mobility.

The present study applied the FTSST and HG strength test to reflect muscle strength of the participants. These components are essential for independent functional mobility. The data are also associated with many health-related outcomes, balance ability, and risk of falls^(20-22,35). The improvement of the HG and FTSST may relate to the exercise program that focused on strengthening with repetitive resistance movements of the trunk, upper extremity and lower extremity. Resistance training could also increase muscle strength through both early neural adaptations, such as increased motor unit recruitment and improved neuromuscular efficiency leading to structural adaptations⁽³⁶⁾. The increased HG strength of 5-6.5 kg has been suggested as the MCID in non-disabled populations⁽³⁵⁾. The decreased time to complete FTSST of 2 seconds as found in this study has been suggested as the MCID in ambulatory individuals with movement impairments⁽³⁷⁾.

As participants were those with severe obesity, the study applied the 1-MST, a short time, promising and cost-effective measure, enabling continuous monitoring physical capability in a small physical space⁽²⁵⁾. The improvement in the 1-MST suggested the benefit of exercise program that lasted 60 - 90 minutes/session over 2 weeks in enhancing oxygen utilization and energy production efficiently within a short training period⁽²⁵⁾. In addition, the program helped to increase flexibility and joint range of motion that is crucial for individuals with severe obesity, who suffer from movement limitations due to excessive adiposity and increased joint stress⁽³⁸⁾. In physiological perspective, increased flexibility is related to adaptations in connective tissue structure and a reduction in passive resistance of muscles and tendons, leading to greater joint mobility and more efficient movement^(24,39). Therefore, the improvement in flexibility observed in this study may contribute to overall physical fitness in the participants.

The present findings support the feasibility and benefit of a two-week exercise in combination of dietary control proposed in this study for the participants with severe obesity scheduled for undergoing bariatric surgery. However, this study contained some limitations. The study had a relatively small number of sample size without clear follow-up data for complications that might occur after the surgery, and postoperative recovery. A future study should apply a randomized controlled trial with prospective data follow-up for treatment effectiveness, postoperative recovery, and the occurrence of complications in the participants.

Conclusion

Ten sessions of 60- to 90-minute exercise program combined with dietary control effectively reduced bodyweight and BMI while improved physical fitness of individuals with severe obesity prepared for bariatric surgery. The improvements of these variables are crucial for reducing the risk of complications and promoting postoperative recovery. Therefore, the program proposed in this study may be applied as an effective and practical approach within healthcare systems, especially in settings with time constraints.

Take home messages

Ten sessions, with approximately 60-90 minutes/session, preoperative program, combining stretching exercise, weight training, cardiovascular exercise, and dietary control can be clinically applied as an effective program for bodyweight reduction and physical fitness improvement among individuals with severe obesity scheduled for undergoing bariatric surgery.

Conflicts of interest

The authors declare no conflict of interest.

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Data availability

Data available on request from the author

Generative AI Declaration

This manuscript utilized the Chat GPT to improve clarity of the images. Following the use of this tool, the authors thoroughly reviewed and edited the materials as necessary, and assume full responsibility for the content of this published article.

References

1. World Health Organization. Thailand's leadership in the fight against obesity: Changing the system for healthier lives [Internet]. 2025 Mar 7 [cited 2026 Jul 27]. Available from: <https://www.who.int/thailand/news/feature-stories/detail/thailand-s-leadership-in-the-fight-against-obesity>
2. Jitnarin N, Kosulwat V, Rojroongwasinkul N, Boonpradern A, Haddock CK, Poston WS. Prevalence of overweight and obesity in

- Thai population: results of the national Thai food consumption survey. *Eat Weight Disord* 2011;16(4):e242-9. doi: 10.1007/BF03327467.
3. Damrath M, Hromiak M, Wilczyński B, Gierat-Haponiuk K. Anthropometric, functional, and haemodynamic changes in bariatric surgery patients within the polish KOS-BAR Pathway: a retrospective cohort study. *Diagnostics (Basel)* 2026;16(11):1736. doi: 10.3390/diagnostics16111736.
 4. Grant B, Sandelson M, Agyemang-Prempeh B, Zalin A. Managing obesity in people with type 2 diabetes. *Clin Med J R Coll Physicians Lond* 2021; 21: E327-31.
 5. Boutari C, DeMarsilis A, Mantzoros CS. Obesity and diabetes. *Diabetes Res Clin Pract* 2023; 202: 110773.
 6. Jung MH, Shin MS. Obesity-related heart failure with preserved ejection fraction: diagnostic and therapeutic challenges. *Korean J Inter Med* 2023;38: 157-66.
 7. Pouwels S, Sanches EE, Cagiltay E, Severin R, Philips SA. Perioperative exercise therapy in bariatric surgery: improving patient outcomes. *Diabetes Metab Syndr Obes* 2020;25(13): 1813-23. doi: 10.2147/DMSO.S215157.
 8. Eisenberg D, Shikora SA, Aarts E, Aminian A, Angrisani L, Cohen RV, et al. 2022 American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO): Indications for metabolic and bariatric surgery. *Surg Obes Relat Dis* 2022;18: 1345-56.
 9. Ram Sohan P, Mahakalkar C, Kshirsagar S, Bikkumalla S, Reddy S, Hatewar A, et al. Long-term effectiveness and outcomes of bariatric surgery: a comprehensive review of current evidence and emerging trends. *Cureus* 2024;16: e66500.
 10. Techagumpuch A, Pantanakul S, Chansaenroj P, Boonyagard N, Wittayapairoch J, Poonthananiwatkul T, et al. Thai society for metabolic and bariatric surgery consensus guideline on bariatric surgery for the treatment of obese patient in Thailand. *J Med Assoc Thai* 2020;103:300-7.
 11. De Luca M, Belluzzi A, Salminen P, Bueter M, Pujol-Rafols J, Sakran N, et al. Development of the International Federation for Surgery of Obesity and Metabolic Disorders-European Chapter (IFSO-EC) grade-based guidelines on the surgical treatment of obesity using multimodal strategies: design and methodological aspects. *J Clin Med* 2024;13(17):5106. doi:10.3390/jcm13175106.
 12. Banasiewicz T, Kobiela J, Cwaliński J, Spychalski P, Przybylska P, Kornacka K, et al. Recommendations on the use of prehabilitation, i.e. comprehensive preparation of the patient for surgery. *Pol Przegl Chir* 2023;95(4):62-91. doi:10.5604/01.3001.0053.8854.
 13. Shilton H, Gao Y, Nerlekar N, Evennett N, Ram R, Beban G. Pre-operative bariatric clinic attendance is a predictor of post-operative clinic attendance and weight loss outcomes. *Obes Surg* 2019;29:2270-5.
 14. Conaty EA, Bonamici NJ, Gitelis ME, Johnson BJ, DeAsis F, Carbray JM, et al. Efficacy of a required preoperative weight loss program for patients undergoing bariatric surgery. *J Gastrointest Surg* 2016;20:667-73.
 15. Stegen S, Derave W, Calders P, Van Laethem C, Pattyn P. Physical fitness in morbidly obese patients: effect of gastric bypass surgery. *Obes Surg* 2011; 21(1): 61-70.
 16. Jiang Z, Larsen M, Alian A, Baillie C, de Beaux AC, O’Kane M, et al. A systematic review of body contouring surgery in post-bariatric patients to determine its prevalence, effects on quality of life, desire, and barriers. *Obes Rev* 2021;22(5):e13201.
 17. Cetin D, Kucuk Yetgin M, Turkcapan AG, Koksalan B, Durmaz S. Effect of corrective exercise on static balance, food consumption, and body composition in the early period after bariatric surgery. *Obes Surg* 2024; 34(5):1449-63. doi: 10.1007/s11695-024-07136-1.
 18. Campos GM, Mazzini GS, Altieri MS, Docimo S Jr, DeMaria EJ, Rogers AM; Clinical Issues Committee of the American Society for Metabolic and Bariatric Surgery. ASMBS

- position statement on the rationale for performance of upper gastrointestinal endoscopy before and after metabolic and bariatric surgery. *Surg Obes Relat Dis* 2021;17(5):837-47. doi: 10.1016/j.soard.2021.03.007.
19. Leahy CR, Luning A. Review of nutritional guidelines for patients undergoing bariatric surgery. *AORN J* 2015;102:153-60.
 20. Pratt J, Paolucci N, Boreham C, De Vito G. Grip strength positively correlates with blood pressure in individuals with abnormal adiposity. *J Hum Hypertens* 2024;38(2):110-9. doi:10.1038/s41371-023-00862-6.
 21. Hardy K, Kwok K, Bouchard DR, Bharti N, Gamey D, Vergis A. Impact of a preoperative exercise program on general fitness in patients awaiting bariatric surgery: a pilot randomized trial. *Cureus* 2022;14(2):e22566. doi:10.7759/cureus.22566.
 22. Özsoy G, Gedikli Y, Altunok MK, Arı Gedik B, Ertürk N, Özsoy İ. Tele-assessment reliability of functional performance tests in adults with obesity. *Digit Health* 2026;12:20552076261417854. doi:10.1177/20552076261417854
 23. de Melo TA, Silva Guimarães F, Lapa e Silva JR. The five times sit-to-stand test: safety, validity and reliability with critical care survivors at ICU discharge *Arch Physiother*. 2022;13(1):2. doi:10.1186/s40945-022-00156-z.
 24. Chen HH, Chen HL, Lin YT, Lin CW, Ho CC, Lin HY, Lee PF. The associations between functional fitness test performance and abdominal obesity in healthy elderly people: results from the national physical fitness examination survey in Taiwan. *Int J Environ Res Public Health* 2020; 18(1): 264.
 25. Pessoa BV, Arcuri JF, Labadessa IG, Costa JN, Sentanin AC, Di Lorenzo VAP, et al. Validity of step tests for the evaluation of exercise capacity: a systematic review. *Clin Rehabil* 2021;35(6):737-53.
 26. Gurd BJ, Perry CG, Heigenhauser GJ, Spriet LL, Bonen A. High-intensity interval training increases SIRT1 activity in human skeletal muscle. *Appl Physiol Nutr Metab* 2010; 35(3): 350-7.
 27. Riebe D, Franklin BA, Thompson PD, Garber CE, Whitfield GP, Magal M, Pescatello LS. Updating ACSM's recommendations for exercise preparticipation health screening. *Med Sci Sports Exerc* 2015;47(11):2473-9. doi:10.1249/MSS.0000000000000664.
 28. Gillis C, Carli F. Promoting perioperative metabolic and nutritional care. *Anesthesiology* 2015; 123(6): 1455-72.
 29. Joyner MJ, Coyle EF. Endurance exercise performance: the physiology of champions. *J Physiol* 2008; 586(1): 35-44.
 30. Colles SL, Dixon JB, Marks P, Strauss BJ, O'Brien PE. Preoperative weight loss with a very-low-energy diet: quantitation of changes in liver and abdominal fat by serial imaging. *Am J Clin Nutr* 2006; 84(2): 304-11.
 31. Marc-Hernández A, Ruiz-Tovar J, Aracil A, Guillén S, Moya-Ramón M. Impact of exercise on body composition and cardiometabolic risk factors in patients awaiting bariatric surgery. *Obes Surg* 2019; 29(12): 3891-900. doi:10.1007/s11695-019-04088-9.
 32. Hall KD, Heymsfield SB, Kemnitz JW, Klein S, Schoeller DA, Speakman JR. Energy balance and its components: implications for body weight regulation. *Am J Clin Nutr* 2012; 95(4): 989-94. doi: 10.3945/ajcn.112.036350.
 33. Hall KD. Predicting metabolic adaptation, body weight change, and energy intake in humans. *Am J Physiol Endocrinol Metab* 2010;298(3). doi:10.1152/ajpendo.00559.2009.
 34. Jakicic JM, Rogers RJ, Davis KK, Collins KA. Role of physical activity and exercise in treating patients with overweight and obesity. *Clin Chem* 2019; 65(1): 99-107.
 35. Bohannon RW. Minimal clinically important difference for grip strength: a systematic review. *J Phys Ther Sci* 2019; 31(1): 75-8.
 36. Grgic J, Schoenfeld BJ, Davies TB, Lazinica B, Krieger JW, Pedisic Z. Effect of resistance training frequency on gains in muscular strength: a systematic review and meta-analysis. *Sports Med* 2020; 50(7): 1201-12.

37. Amatachaya S, Khuna L, Thaweewannakij T. Responsiveness and minimal clinically important difference of the five times sit-to-stand test in ambulatory individuals with spinal cord injury: A six-month prospective cohort study. *Clin Rehabil* 2023; 37(1): 109-18.
38. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. Musculoskeletal disorders associated with obesity: a biomechanical perspective. *Obes Rev* 2006; 7(3): 239-50.
39. Freitas SR, Mendes B, Le Sant G, Andrade RJ, Nordez A, Milanovic Z. Can chronic stretching change muscle architecture? A systematic review. *Scand J Med Sci Sports* 2018; 28(3): 794-806.

Rehabilitation in a patient with recent diagnosis of dementia: the physiatrist and the geriatrician compared in taking charge of a case report

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KEYWORDS

Spinal surgery;
Rehabilitation;
Movement disorders;
Parkinsonism;
Dementia.

ABSTRACT

The rehabilitation of a patient suffering from multiple comorbidities and locomotor disabilities was a difficult task from which the physiatrist does not shy away. The rehabilitation work was even more complex when a new diagnosis of dementia is added to these problems. An elderly patient with numerous comorbidities was hospitalized for spinal surgery and subsequently suffered from infectious complications. In fact, he underwent T12-L1 decompressive laminectomy surgery due to a stenosis of the spinal canal at the T12-L1 levels with myelopathy which was already manifested itself in the past with weakness in the right lower limb and presence of worsening lumbocruralgia with impaired walking. The patient was referred to have rehabilitation programs to regain his independence. However, during his hospitalization, he showed clinical signs that led to a suspected diagnosis of parkinsonism. Subsequently, he was diagnosed with cognitive impairments with frontotemporal dementia. A Parkinson-plus syndrome, also called atypical parkinsonism, is referred to a group of neurodegenerative movement disorders that resemble idiopathic Parkinson's disease with certain distinguished clinical and pathophysiological features. In this regard, we described a clinical case report in which the skills of the geriatrician and those of the physiatrist were called upon to collaborate closely to take charge of this complex patient.

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Introduction

While there is experience, despite many doubts, regarding the benefits of physical activity and physiotherapy on the cognitive effects of individuals suffering from dementia^(1,2), there is little evidence on the physiotherapy protocols in these patients who present with pathologies of physiotherapy relevance⁽³⁾. Taking care of these patients still constitutes a major challenge today that puts the knowledge and skills of the various professional involvements. This paper describes a complex clinical case that came to our attention due to rehabilitation problems, which led to a new diagnosis of a previously unrecognized dementia, which constituted a challenge in which psychiatrists and geriatricians faced.

Methods

Clinical history

An elderly patient, aged 88 years old, with childhood polio and a past medical history of glaucoma, had left knee prosthesis due to knee osteoarthritis (2016), osteosynthesis in left femur fracture (2017) and osteosynthesis with intramedullary nail for right femur pertrochanteric fracture (2018). The patient underwent decompressive laminectomy at T12-L1 due to spinal stenosis with myelopathy. The spinal cord damage manifested itself with lumbocruralgia, weakness in the right lower limb, and walking difficulty, whereby the lesion was initially unrecognized due to the effects of childhood polio. However, the laminectomy operation was subject to infectious complications, i.e., epidural collection with moderate compression on the dural sac. Thus, the patient needed a revision of the thoracolumbar epidural surgical wound with mostly epifascial collection evacuation. Then, the general and neurological conditions were improved with antibiotic therapy.

Upon the start of the intensive rehabilitation program, the patient appeared with quite alert, partially cooperative and oriented in the three axes, and generalized hyponotrophy in arthrosis

pattern. The patient was dependent in basic and instrumental activities of daily life (ADL and IADL), with the need for moderate assistance in postural transitions and transferring. He assumed the sitting position for a few seconds due to early fatigue, and was unable to stand upright or walking.

Treatments and progression

We initially set up an individual rehabilitation project (PRI) aimed at preventing secondary damage from hypokinesia and maintaining joint excursion. In addition, the treatments aimed to improved muscular strength of the lower limbs, as well as trunk and pelvis control to promote sitting position, and independent in the various ADLs and IADLs. The patient remained haemodynamically stable, eupnoeic at rest in room air and afebrile, with the absence of significant internal medical complications. However, he showed a progressive and rapid vigilance and cognitive function decline with a decrease in motor functional status.

Upon subsequent re-evaluation during a week later, he appeared disoriented and apathetic with very little verbal and motor initiative. He also presented obvious signs of parkinsonism with marked rigidity and diffuse bradykinesia, dystonic attitude of the neck. There was also the presence of a fine tremor of the right upper limb. There was no clinical improvement after a five-day treatment with rotigotine before and only slight improvement was observed with levodopa. Therefore, since we suspected a form of parkinsonism plus syndrome, we decided to perform Magnetic Resonance Imaging (MRI) for the patient (Figure 1). The data showed striking signs of regressive-atrophic cortico-subcortical manifestations with prevalent symmetrical and bilateral involvement of the frontal and temporal lobes, with associated signs of leukoencephalopathy on a chronic vasculopathic basis. The images also document widespread and bilateral regressive cortico-subcortical alterations in both cerebral hemispheres, with prevalent involvement of the frontal and temporal lobes.

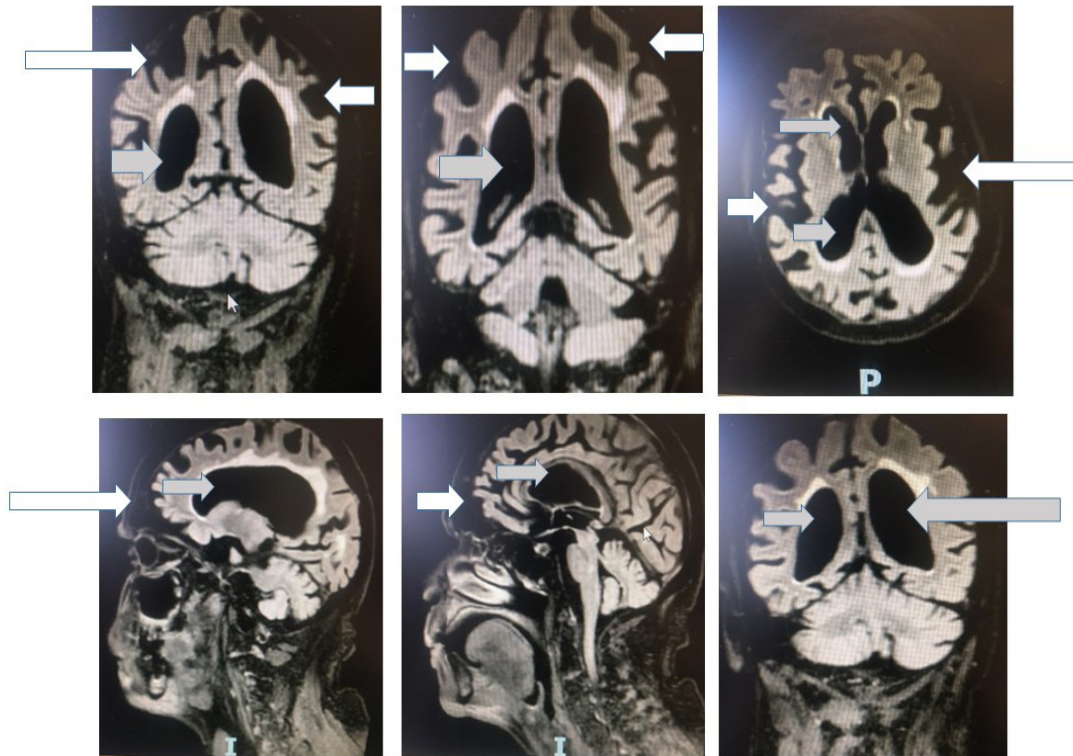


Figure 1 Brain Magnetic Resonance Imaging (MRI) with Field Echo, Fluid Attenuated Inversion Recovery, Diffusion Weighted Imaging, 3D T1-weighted volumetric sequence, Susceptibility Weighted Angiography/Imaging (SWAN), and Magnetization Prepared Rapid Gradient Echo (3D MP-RAGE) sequences, according to multiple planes, of the patient. The arrows highlight the areas of regression at the cortical and subcortical levels in both cerebral hemispheres. It is clear, highlighted by the arrows, how these regressive alterations are present especially at the frontal and temporal levels bilaterally. The arrows also highlight the dilation of the ventricular system and the Sylvian cisterns and the periencephalic CSF spaces bilaterally.

We referred the patient to receive neuropsychological tests. The findings revealed the presence of multiple deficits, especially regarding planning, with absence of cognitive flexibility, working memory and inhibition, and voluntary responses, indicative of a deficit in executive functions on the dorsolateral prefrontal cortex⁽⁴⁻⁷⁾. Consequently, the patient was diagnosed with parkinsonism-plus syndrome in behavioural variant of frontotemporal dementia (bvFTD). Thus, the rehabilitation goals were set to preserve remaining ADLs for as long as possible, managing disability and quality of life, and adapting to the (often very rapid) progression of the disease.

Subsequently, the PRI was intensified with assisted active kinesitherapy and exercises for the recovery of strength of the four limbs, pelvic girdle, trunk stability, and balance control while sitting. In addition, the patient received training programs for postural changes and safe transfers, along with the nursing assistance in the elementary daily activities. During hospitalization, the PRI was provided to also ensure partially active range of motion of the upper and lower extremities scapulo-humeral, elbow and wrists (due to concomitant arthrosis), right and left shoulder flexion limited to medium grades with mild pain symptoms. Thereafter, there was a slight improvement in the

muscle strength deficit of the hip flexors (strength from 1/5 of the Medical Research Council or MRC) at the beginning of the PRI to 2/5), the hip adductors and abductors (from 2/5 to 3/5 MRC), the knee flexors and extensors (from 1/5 to 2/5 MRC), the triceps surae (from 2/5 to 3/5 MRC), the anterior and posterior tibialis muscles (from 1/5 to 2/5 MRC). Similar findings were also observed in the left lower limb. Muscle tone was partially recovered in both lower limbs, in the absence of objective sensitivity deficits. We then set up a pharmacological therapy with vortioxetine 20 mg, zopiclone 7.5 mg, pregabalin 150 mg, esomeprazole 40 mg, enoxaparin 4000 IU and tamsulosin 0.4 mg, ensuring hydration for 24 hours.

Finally, we informed the family members about the patient's condition, the possibilities of recovery, the maintenance of residual functions and progression of the dementia pathology, with the consent of a family member and appointing a support administrator. Then, we proceeded to prescribe all aids to facilitate recovery in the patient's home care with the initiation of home physiotherapy services. Finally, we planned serial monitoring for executive functions using neuropsychological tests (with preferential choice on the Clock Drawing Test, the attentional matrices test, the Phonemic and Semantic Verbal Fluency Test and the apathy evaluation scale).

Discussion

The described case report places emphasis primarily on the need for close collaboration between physiatrist and geriatrician for appropriate treatments of the patient. Parkinson-plus syndrome, also called atypical parkinsonism, refers to a group of neurodegenerative movement disorders that resemble idiopathic Parkinson's disease with certain distinguishing clinical and pathophysiological features⁽⁴⁾ (Table 1). The clinical signs associated with the poor response to anti-parkinsonian therapy had increased our suspicion, confirmed by the imaging findings. Frontotemporal dementia (FTD) is a neurodegenerative disease that accounts

for up to 10% of middle-age-onset dementias and entails a social, economic, and emotional burden for the patients and caregivers⁽⁵⁾. Approximately 40% of people with FTD report a family history of dementia, motor neuron disease or parkinsonism, and half of these familial cases are attributed to genetic mutations. For this reason, we explored the anamnesis in the subject's family tree^(6,7). There is no significant scientific evidence regarding the conduct to be followed in the rehabilitation of patients suffering from dementia and orthopedic problems. The majority of publications concern individuals with femoral fracture (which was however present in our patient as a previous pathology) and with less than brilliant results^(8,9). A study by Poletti et al⁽¹⁰⁾ highlights the value of neuropsychological tests that allow early identification of the deficits affecting cognitive functions, in particular executive functions, connected to the prefrontal cortex. Neuropsychological tests can also demonstrate the extent to which cognitive functions are maintained or improved, providing a more concrete evaluation of the rehabilitation's efficacy⁽¹¹⁾. To our knowledge, there is no study reporting effectiveness of rehabilitation protocols of an individual suffering from FTD with disabilities of osteomuscular etiology that increases burdensome and complexity for the rehabilitation process of the patient. In addition, the behavioural variant of frontotemporal dementia (bvFTD) is characterized by changes in personality and social interaction, loss of empathy placing the individual in a condition where he is no longer able to look after himself not only from an ADL and IADL point of view, but precisely as a legal person. In fact, the behavioral symptoms of bvFTD can have legal implications. Loss of social control, profound apathy, repetitive or compulsive behaviors, changes in appetite, a marked reduction in empathy toward others—a whole range of unique behaviors—can have detrimental effects on patients and their families. For this reason, one of the tasks of the dementia physician is to address the legal aspects of behaviors induced

by a neuropsychiatric condition. In this clinical case, therefore, interviews with family members and counseling regarding the role of a family

member as a support guardian were part of our assessment, along with the clinical diagnoses and prognoses quoad vitam and quoad valitudinem.⁽¹²⁾

Table 1 Classification of parkinsonism plus syndromes⁽¹³⁾

<u>Sporadic</u> 1. Progressive supranuclear palsy (PSP) 2. Multiple system atrophy (Striatonigral degeneration) 3. Olivoponto cerebellar atrophy, Shy-Drager syndrome) (MSA), Cortical-basal ganglionic degeneration (CBGD) 4. Diffuse Lewy body disease (DLB) 5. Sporadic pallidal degeneration and related disorders 6. Bilateral striatopallido dentate calcinosis 7. Parkinsonism with neuroacanthocytosis
<u>Familial</u> 1. Associated with dementia a. Fronto temporal dementia and Parkinsonism linked to chromosome 17 b. Familial dementia with swollen achromatic neurons and cortico-basal inclusion bodies c. Familial diffuse Lewy body disease 2. Associated with psychiatric and respiratory disturbances 3. Associated with other types of movement disorders: $\left\{ \begin{array}{l} \text{a. Dystonia} \\ \text{b. Myoclonus and seizures} \\ \text{c. Others} \end{array} \right.$ 4. Associated with eye movement abnormalities: $\left\{ \begin{array}{l} \text{a. Familial progressive supranuclear palsy} \end{array} \right.$ 5. Others

Conclusion

Through a collaborative approach, a specialized healthcare team—comprising a physiatrist, geriatrician, physiotherapist, and nurse—achieved a precise diagnosis for a complex dementia patient, successfully preventing misclassifications that could have triggered severe clinical complications. Although the revised diagnosis revealed a challenging rehabilitation prognosis, targeted physical interventions successfully preserved muscle tone and trophism while preventing sarcopenia, bedsores, and life-threatening immobility. Ultimately, these clinical efforts enabled a safe return home, reinforced by essential adaptive equipment and multidimensional guidance designed to manage patient frailty and protect caregivers from stress and burnout. This singular case underscores the immense value

of integrating evidence-based protocols with experience-informed practice to guide multi-professional care for complex dementia populations.

Take home messages

Early recognition of Parkinsonism-plus is critical to avoid mistaking neurodegenerative postural deficits for mechanical spine issues, preventing unnecessary spinal surgery. Dedicated management by geriatricians and physiatrists ensures timely diagnosis, while tailored physiotherapy helps manage severe motor symptoms, reduce fall risks, and preserve patient independence and quality of life.

Conflicts of interest

The authors declare no conflict of interest.

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Author contributions

Magro VM served as the primary researcher and was solely responsible for conceptualization, methodology, clinical case management, and drafting the original manuscript, as well as its critical revision and final modifications.

Data availability

The datasets generated and analyzed during the current study are not available due to privacy reasons but are available from the corresponding author upon reasonable request.

Statement of ethics

This retrospective review of patient data did not require ethical approval in accordance with local/ national guidelines.

References

1. Zhu XC, Yu Y, Wang HF, Jiang T, Cao L, Wang C, et al. Physiotherapy intervention in Alzheimer's disease: systematic review and meta-analysis. *J Alzheimers Dis* 2015; 44(1): 163-74.
2. Saúde A, Bouça-Machado R, Leitão M, Benedetti A, Ferreira JJ. The Efficacy and safety of physiotherapy in people with dementia: a systematic review. *J Alzheimers Dis* 2023; 94(3): 909-17
3. Hall AJ, Lang IA, Endacott R, Hall A, Goodwin VA. Physiotherapy interventions for people with dementia and a hip fracture-a scoping review of the literature. *Physiotherapy* 2017; 103(4): 361-8.
4. Vertes AC, Beato MR, Sonne J, Khan Suheb MZ. Parkinson-Plus Syndrome. 2023 Jun 1. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026
5. Antonioni A, Raho EM, Lopriore P, Pace AP, Latino RR, Assogna M, et al. Frontotemporal Dementia, Where Do We Stand? A Narrative Review. *Int J Mol Sci* 2023; 24(14): 11732.
6. Rowe JB. Parkinsonism in frontotemporal dementias. *Int Rev Neurobiol* 2019; 149: 249-75.
7. Ferrari R, Hernandez DG, Nalls MA, Rohrer JD, Ramasamy A, Kwok JB, et al. Frontotemporal dementia and its subtypes: a genome-wide association study. *Lancet Neurol* 2014; 13(7): 686-99.
8. Romero Pisonero E, Mora Fernández J. Multidisciplinary geriatric rehabilitation in the patient with hip fracture and dementia. *Rev Esp Geriatr Gerontol* 2019; 54(4): 220-229. Spanish.
9. Hall AJ, Fullam J, Lang IA, Endacott R, Goodwin VA. Community physiotherapy for people with dementia following hip fracture: Fact or fiction? A qualitative study. *Dementia* (London). 2020; 19(8): 2750-60.
10. Poletti M, Bonuccelli U. Psychopathological spectrum in behavioral variant frontotemporal dementia. *Riv Psichiatri* 2013; 48(2): 146-54. Italian.
11. Devenney E, Bartley L, Hoon C, O'Callaghan C, Kumfor F, Hornberger M, et al. Progression in Behavioral Variant Frontotemporal Dementia: A Longitudinal Study. *JAMA Neurol* 2015; 72(12): 1501-9.
12. Manes F, Torralva T, Ibáñez A, Roca M, Bekinschtein T, Gleichgerrcht E. Decision-making in frontotemporal dementia: clinical, theoretical and legal implications. *Dement Geriatr Cogn Disord* 2011; 32(1): 11-7.
13. Mitra K, Gangopadhaya PK, Das SK. Parkinsonism plus syndrome--a review. *Neurol India*. 2003; 51(2):183-8.