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One-year effectiveness of high-load compared with low-load strengthening exercise on self-reported function in patients with hypermobile shoulders: a secondary analysis from a randomised controlled trial

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ABSTRACT

Objectives To investigate the long-term effectiveness of high-load versus low-load strengthening exercise on self-reported function in patients with hypermobility spectrum disorder (HSD) and shoulder symptoms.

Methods A secondary analysis of a superiority, parallel-group, randomised trial (balanced block randomisation 1:1, electronic concealment) including adult patients (n=100) from primary care with HSD and shoulder pain and/or instability ≥3 months. Patients received 16 weeks of shoulder exercises (three sessions/week): HEAVY (n=50, full-range, high-load, supervised twice/week) or LIGHT (n=50, neutral/mid-range, low-load, supervised three times in total). The 1-year between-group difference in change in self-reported function was measured using the Western Ontario Shoulder Instability Index (WOSI, scale 0–2100, 0=best). Secondary outcomes were self-reported measures including changes in shoulder-related symptoms, function, emotions and lifestyle, quality of life, patient-perceived effect, treatment utility and adverse events. A blinded analyst conducted the analyses using linear mixed model repeated measurements analysis.

Results One-year data were available in 86 out of 100 participants (79% women, mean age 37.8 years) (LIGHT 84%, HEAVY 88%). The mean WOSI score between-group difference favoured HEAVY (−92.9, 95% CI −257.4 to 71.5, p=0.268) but was not statistically significant. The secondary outcomes were mostly inconclusive, but patients in HEAVY had larger improvement in the WOSI emotions subdomain (−36.3; 95% CI −65.4 to −7.3, p=0.014). Patient-perceived effect favoured HEAVY anchored in WOSI-emotions (55% vs 31%, p=0.027) and WOSI-lifestyle (50% vs 29%, p=0.042).

Conclusion High-load shoulder strengthening exercise was not superior to low-load strengthening exercise in improving self-reported function at 1 year. High-load strengthening exercise may be more effective in improving patient emotions about shoulder pain and function, but more robust data are needed to support these findings.

Trial registration number NCT03869307.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Four of five patients with hypermobility spectrum disorder (HSD) experience shoulder symptoms (pain and/or instability).
⇒ A supervised, progressive high-load shoulder strengthening exercise programme (full-range, open kinetic chain) resulted in greater self-reported improvements in shoulder function than less supervised and less progressive low-load exercises (neutral to midrange) at 16 weeks in patients with HSD and shoulder pain and/or shoulder instability.

WHAT THIS STUDY ADDS

⇒ At 1 year, a high-load shoulder strengthening exercise programme was not superior to low-load exercises on self-reported improvements in shoulder function in patients with HSD and shoulder pain and/or shoulder instability.
⇒ In a subdomain analysis, high-load shoulder strengthening exercise may improve patients' perceptions about their shoulder pain and function in the long term, but more robust data are needed to support these findings.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Both exercise interventions result in clinically meaningful improvements at 1 year and are viable treatment options to improve shoulder function in the long term.
⇒ Further studies are needed to confirm subgroups of patients that may benefit from high-load versus low-load strengthening exercise.

INTRODUCTION

Joint hypermobility is defined as movements beyond the joint's normal range, and its prevalence varies from 2% to 57% and is influenced by several factors such as age, race, sex and injury.[1 2] The most common symptomatic joint hypermobility condition is hypermobility spectrum disorder (HSD).[3] The major complaint of individuals with HSD is chronic/long-lasting musculoskeletal pain that affects daily activities and reduces quality of life[2 4] In addition to pain, individuals with HSD may experience muscle weakness, fatigue, joint instability, impaired balance and altered motor performance, for example, decreased walking

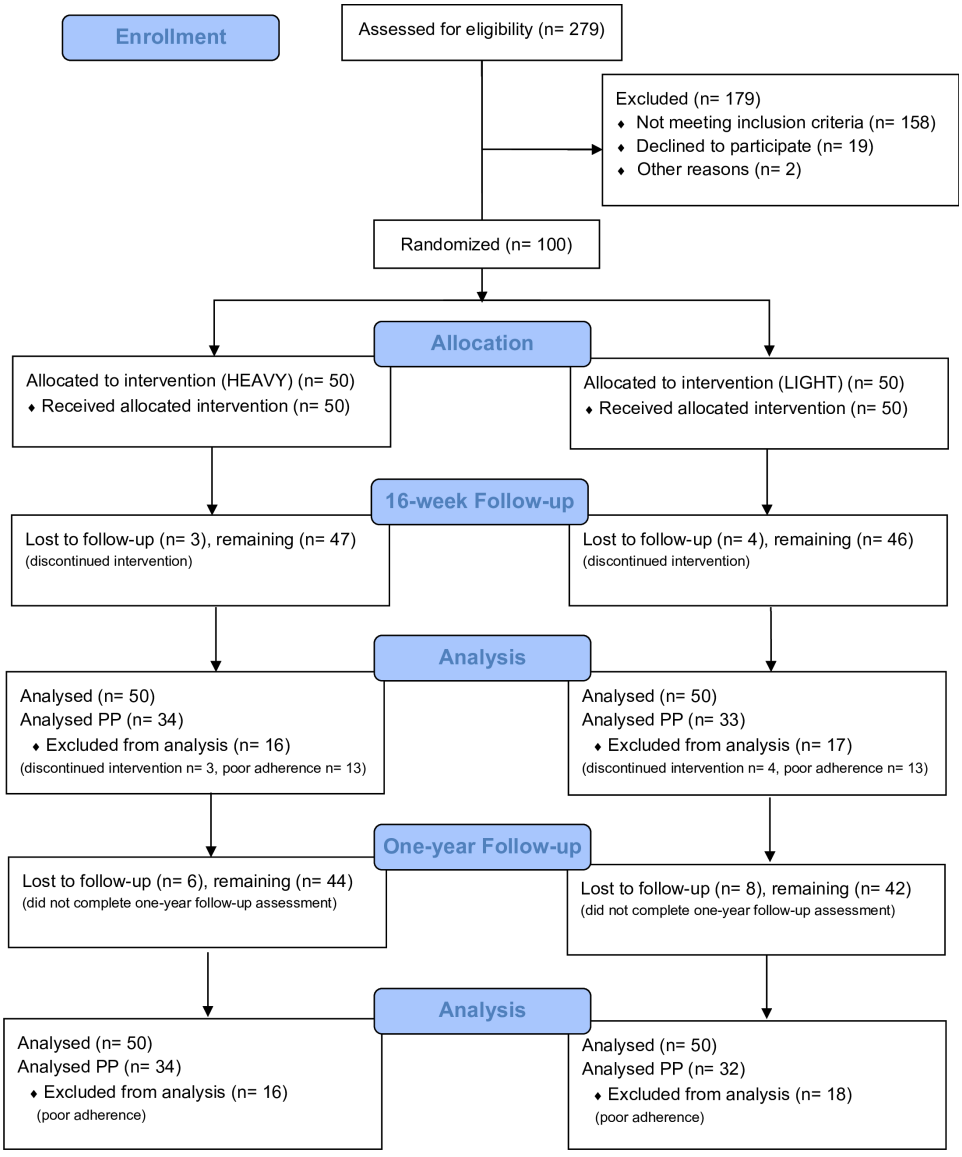

Figure 1 Consolidated Standards of Reporting Trials (CONSORT) flow diagram. HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise. PP, per-protocol.

distance.[2 5] Furthermore, individuals commonly exhibit psychological symptoms such as depression and anxiety.[6] Symptoms such as chronic pain and instability affect the shoulder joint in more than four out of five individuals with HSD, affecting daily life.[7–9] Previous studies indicate that these individuals may benefit from a multidisciplinary approach involving exercise therapy, cognitive–behavioural therapy, pharmacotherapy and self-management, even though this is based on sparse evidence.[3 4 10] Current guidelines recommend low-load strengthening exercise for individuals with HSD.[11] Due to uncertainty about the effectiveness of high-load strengthening exercises and patient safety, high-load strengthening exercises are seldom used.[11 12] However, high-load strengthening exercise may be an effective tool for individuals with HSD. In a randomised controlled trial (RCT), data suggested that supervised and progressive high-load strengthening exercise was superior to less supervised and less progressive low-load exercise at 16-week follow-up.[12] Interestingly, no serious adverse events were reported during the study period.[12] This secondary analysis aimed to evaluate the long-term effectiveness on improvement in self-reported function. Our primary hypothesis was that the larger improvement in high-load shoulder strengthening exercise compared with low-load exercise (standard care) was maintained at 1-year follow-up.

METHODS

Design and setting

This report includes the 1-year results of an assessor-blinded, multicentre superiority RCT[12] that compared high-load versus low-load strengthening exercise on self-reported shoulder function in patients with HSD and shoulder symptoms. The participants, recruited between March 2019 and September 2020 from primary care within the Region of Southern Denmark, received the intervention during 16 weeks. Four blinded physiotherapists collected data at baseline and 16-week follow-up at two different locations. At the 1-year follow-up, patients digitally answered the self-reported questionnaires. This report adheres to the Consolidated Standards of Reporting Trials (CONSORT).[13]

Table 1 Baseline characteristics for the intervention (HEAVY) and comparator (LIGHT)

Variables	LIGHT (n=50)	HEAVY (n=50)
Sex (female), n (%)	39 (78)	40 (80)
Age (years)	37.0 (12.0)	38.6 (13.6)
Weight (kg)	81.6 (16.0)	79.0 (18.5)
Height (cm)	172.4 (9.2)	171.4 (8.9)
Hypermobility spectrum disorder		
Beighton score (scale 0–9)	5.8 (1.8)	5.8 (1.6)
5PQ (scale 0–5)	3.1 (1.2)	2.9 (1.1)
Symptom duration (months), median (IQR)	36 (11.8–87)	43 (14.3–120)
Previous shoulder dislocation (yes), n (%)	8 (16)	10 (20)
Feeling shoulder is loose (yes), n (%)	26 (52)	22 (44)
Primary outcome measure		
WOSI total (scale 0–2100)	1071.5 (379.8)	1042.1 (351.9)

Continuous data presented as mean (SD) or median (IQR), and categorical variables presented as proportion n (%).
HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise; 5PQ, 5-part hypermobility questionnaire; WOSI, Western Ontario Shoulder Instability Index.

Participants

Patients aged 18–65 were eligible if fulfilling the criteria for generalised HSD or historical HSD.[9 12 14] The HSD criteria included generalised joint hypermobility using the Beighton score with a cut-point of 5 for women <50 years of age, 4 for women ≥50 years and 4 for men of all ages.[12 14] Other inclusion criteria were manifestations in the musculoskeletal system, for example, shoulder pain for at least 3 months, joint instability or recurrent joint dislocation without any trauma.[12 15] For historical HSD, we accepted a 1-point lower Beighton score if the 5-part hypermobility questionnaire (5PQ) was positive with a cut-point of 2.[12 16] Patients were excluded if they were diagnosed with competing systemic rheumatic or neurological diseases, had clinically suspected referred pain from the cervical spine and connective tissue diseases, except hypermobile Ehlers-Danlos Syndrome. Further exclusion criteria were pregnancy, planning to get pregnant during the study period or having given birth within the past year (due to increased levels of relaxin), steroid injection in the affected shoulder within the past 3 months, shoulder surgery within the past year, inability to comply with the study protocol or speak or understand Danish, and not giving informed consent.[12 15] Eligible participants answered an online prescreening questionnaire including the 5PQ[16] and questions about their shoulder symptoms in Research Electronic Data Capture (REDCap). Eligible participants, who fulfilled the inclusion criteria and consented to participate, were baseline tested, randomised and appointed the first intervention session within 1 week.[12 15]

To reduce the risk of performance bias, the participants were told that the trial was a comparison of two different exercise protocols to increase shoulder muscle function.[12]

Randomisation, allocation concealment and blinding

An external data manager set up a computer-generated allocation sequence with permuted blocks of 4–6. In REDCap, the randomisation was automatically performed by the project

Table 2 Primary analysis using linear mixed model analysis of repeated measurements for the primary and secondary outcomes including all randomised patients (n=100)

	Between-group difference at 1 year (95% CI) adjusted for site	P value	Between-group difference at 1 year (95% CI) adjusted for baseline and site	P value	Between-group difference from 16 weeks to 1 year (95% CI) adjusted for baseline and site	P value
Primary outcome measure						
WOSI total (scale 0–2100)	−92.9 (−257.4 to 71.5)	0.268	−99.8 (−262.4 to 62.7)	0.229	84.2 (−56.1 to 224.5)	0.239
Secondary self-reported outcomes						
WOSI physical symptoms (scale 0–1000)	−49.5 (−127.2 to 28.2)	0.212	−51.3 (−128 to 25.4)	0.190	29.1 (−40.5 to 98.7)	0.412
WOSI sports/recreation/work (scale 0–400)	1.4 (−40.4 to 43.2)	0.947	−0.5 (−41.8 to 40.7)	0.979	27.3 (−6.9 to 61.6)	0.117
WOSI lifestyle (scale 0–400)	−8.3 (−42.4 to 25.8)	0.632	−9.9 (−43.5 to 23.9)	0.569	20.5 (−8.2 to 49.2)	0.161
WOSI emotions (scale 0–300)	−36.3 (−65.4 to -7.3)	0.014	−37.2 (−65.9 to -8.5)	0.011	7.7 (−18 to 33.5)	0.556
Shoulder pain last 7 days (scale 0–10)						
Lowest rating	−0.04 (−0.8 to 0.7)	0.915	−0.09 (−0.9 to 0.7)	0.824	0.2 (−0.5 to 1)	0.513
Highest rating	−0.3 (−1.5 to 0.8)	0.591	−0.4 (−1.5 to 0.7)	0.479	0.4 (−0.7 to 1.6)	0.473
Average rating	−0.2 (−1.0 to 0.6)	0.600	−0.3 (−1.1 to 0.5)	0.527	0.2 (−0.6 to 1)	0.616
Discomfort due to shoulder symptoms other than pain last 7 days (scale 0–10)						
Lowest rating	−0.4 (−1.3 to 0.4)	0.330	−0.4 (−1.3 to 0.4)	0.328	−0.3 (−1.1 to 0.5)	0.511
Highest rating	−0.6 (−1.6 to 0.4)	0.261	−0.6 (−1.6 to 0.4)	0.240	−0.2 (−1.1 to 0.7)	0.636
Average rating	−0.07 (−0.9 to 0.7)	0.864	−0.1 (−0.9 to 0.7)	0.794	−0.06 (−0.8 to 0.7)	0.885
Patient-Specific-Functional Scale (scale 0–30)	0.2 (−2.7 to 3.1)	0.908	0.1 (−2.8 to 2.9)	0.966	−0.2 (−2.8 to 2.5)	0.913
Checklist Individual Strength (scale 8–56)	−1.6 (−6.2 to 2.9)	0.476	−1.6 (−6 to 2.9)	0.494	0.8 (−4 to 5.5)	0.755
COOP/WONCA (scale 6–30)	0.3 (−1.3 to 2.0)	0.686	0.4 (−1.2 to 2.1)	0.599	0.5 (−1.2 to 2.1)	0.571
Tampa Scale of Kinesiophobia (scale 11–44)	−1.6 (−3.6 to 0.4)	0.111	−1.6 (−3.6 to 0.3)	0.101	−0.9 (−2.8 to 1)	0.364
EQ-5D-5L (scale<0–1)	−0.01 (−0.06 to 0.05)	0.841	−0.00 (−0.06 to 0.05)	0.977	−0.00 (−0.05 to 0.04)	0.883
EQ-VAS (scale 0–100)	−6.8 (−15.3 to 1.7)	0.115	−7.3 (−15.6 to 1)	0.085	−0.8 (−8.9 to 7.3)	0.850
Self-Efficacy Questionnaire (scale 0–60)	−3.4 (−7.3 to 0.4)	0.080	−3.6 (−7.3 to 0.2)	0.066	−1.2 (−4.8 to 2.4)	0.518

COOP/WONCA, Dartmouth Primary Care Cooperative Research Network/World Organization of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians; EQ-5D-5L, European Quality of life-5 Dimensions-5-Level; VAS, Visual Analogue Scale; WOSI, Western Ontario Shoulder Instability Index.

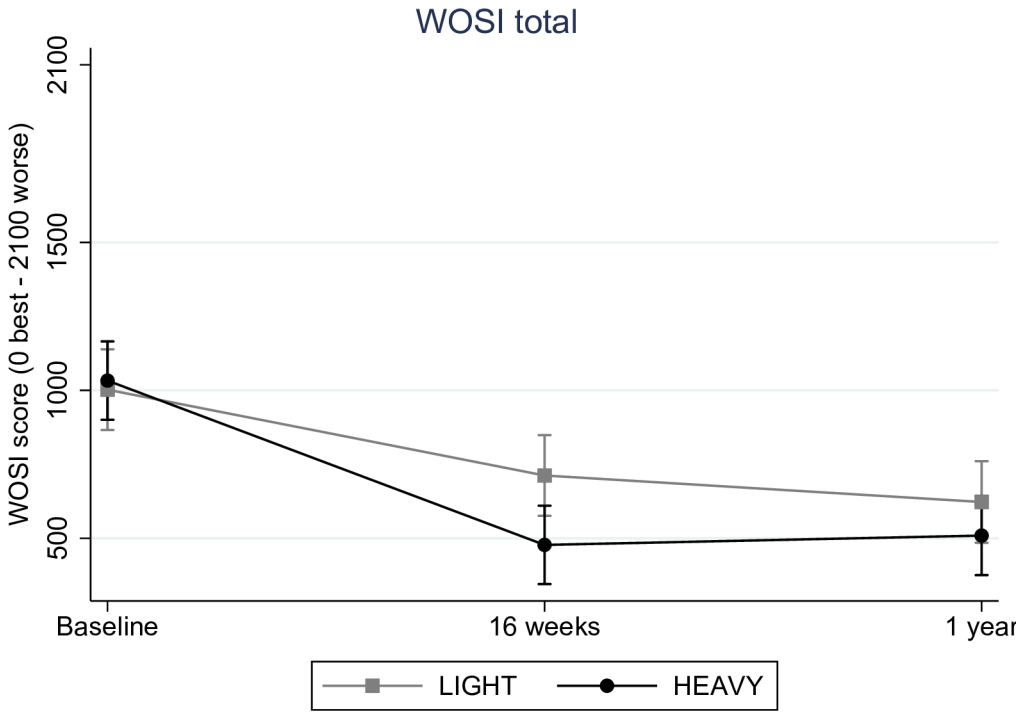

Figure 2 Western Ontario Shoulder Instability Index (WOSI) total scores at baseline, 16 weeks and 1 year. The graph illustrates the results from the primary analysis, with data points representing means and error bars indicating 95% CIs. HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise.

manager. Outcome assessors, the project manager and the principal investigator were blinded to block sizes and unaware of the next assignment in the allocation sequence, which ensures allocation concealment. The physiotherapists who performed the interventions were not blinded to treatment allocation. The project manager informed the participants about group allocation immediately after baseline testing. The data analysis at the 1-year follow-up was performed blinded.[12 15]

Intervention

The participants were randomised into two groups: the intervention group participating in a high-load exercise programme (HEAVY) and the comparator group participating in a low-load exercise programme (LIGHT), both for 16 weeks.[15] The study interventions were performed by one of 23 physiotherapists at a physiotherapy clinic close to the participant's home, whereas home-based exercises could be performed, for example, in the participant's home. All treating physiotherapists underwent a 3-hour long practical and theoretical class tutored by the primary investigator (BL). This was supplemented with education manuals for both LIGHT and HEAVY. Both groups received the same education and instructions about scapular correction and general advice on joint protection.[11 12 15]

Intervention group (HEAVY: high-load exercise)

The intervention group received an exercise programme that included five exercises for the rotator cuff and scapular muscles, and the participants were offered individual supervision twice a week at a physiotherapy clinic.[15 17 18] Once a week, the participants performed exercises without supervision at home or in a self-chosen location. The five exercises were seated shoulder elevation in the scapular plane, prone external rotation at 90° of shoulder abduction, side-lying external rotation in neutral, supine scapular protraction and prone horizontal abduction. These exercises were performed with specially designed three-dimensional printed adjustable dumbbells (0–1000 g) and normal dumbbells (2–15 kg).[15] During the 16 weeks, the exercises were individually progressed based on a 5-repetition maximum (RM) test, which was used to estimate a 10 RM using Brzycki's formula.[19] Week 1 began with 3 sets of 10 at 50% of 10 RM and progressed to 4 sets of 8 RM in weeks 10–15, before 1 week of tapering.[12 15 20 21]

Comparator group (LIGHT: low-load exercise)

The comparator group received home-based exercises three times a week. The programme was designed to mimic standard care in Denmark. The participants received an individual introduction to the exercise programme at baseline and further individual supervision as they initiated new exercises at weeks 5 and 11. Nine exercises for rotator cuff and scapular muscles were included and were performed first without and later with a resistance band. The exercises were three different shoulder movements: abduction, internal rotation and external rotation, performed in three phases. Phase 1 focused on posture correction. Phase 2 was isometric load with 90° flexion in the elbow joint and standing weight-bearing in the shoulders against a table. Phase 3 was dynamic load with a light resistance band in abduction, internal and external rotation and a four-point kneeling position with single arm raises.[12 15]

Outcomes

Primary outcome

The primary outcome in the primary 16-week[12] and this secondary 1-year report was self-reported shoulder function using the Western Ontario Shoulder Instability Index (WOSI), a validated questionnaire developed for patients with shoulder instability with high test–retest reliability and responsive to change.[22 23] A digital Danish,

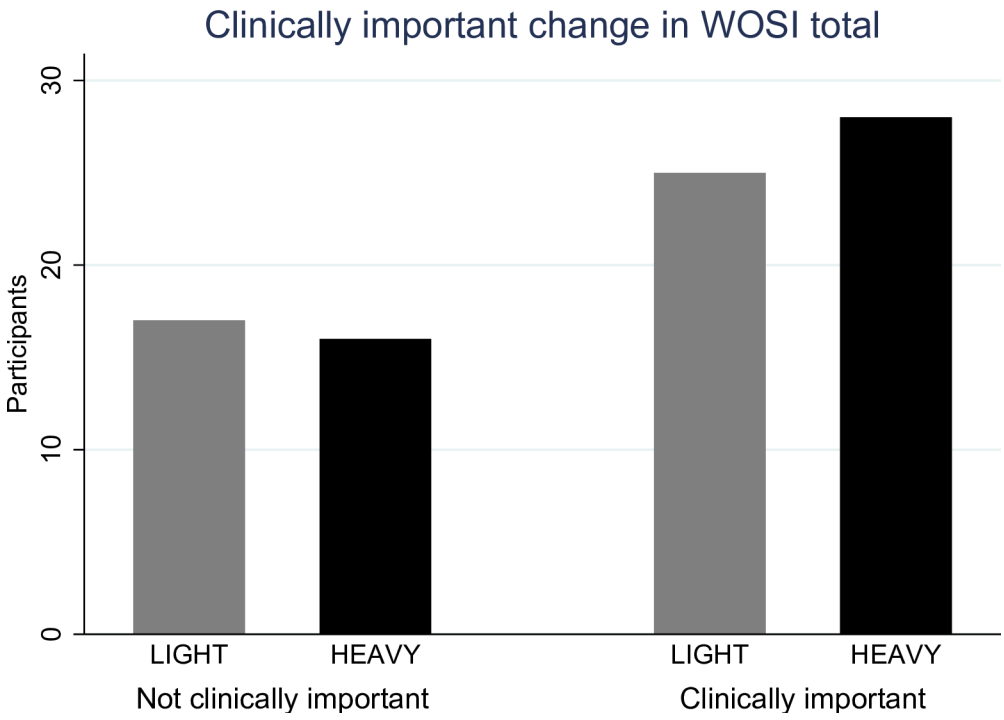

Figure 3 Bar graph showing the number of participants in LIGHT and HEAVY with a clinically important change in WOSI-total score (minimal important difference: 252 points). HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise; WOSI, Western Ontario Shoulder Instability Index.

validated version was used.[22] WOSI has 21 questions with each question scored from 0 to 100, with 0 being best and 100 being worst. The total score ranges from 0 to 2100 points. The 21 questions are divided into four subdomains: physical symptoms (10 questions), sports/recreation/work (4 questions), lifestyle (4 questions) and emotions (3 questions).

Secondary outcomes

The self-reported secondary outcome measures were WOSI subdomains[22]; shoulder pain worst, least and the average for the past week (scale 0–10)[24]; discomfort due to shoulder symptoms other than pain (instability, subluxation, laxity) (scale 0–10)[25]; Patient-Specific Functional Scale (scale 0–30)[26]; Checklist Individual Strength, the subscale of fatigue (scale 8–56)[27]; the Dartmouth Primary Care Cooperative Research Network/World Organisation of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians questionnaire (scale 6–30)[28 29]; Tampa Scale of Kinesiophobia-11 (scale 11–44)[30]; European Quality of life (EQ)-5 Dimensions-5-Level Scale (scale 0–1)[31 32]; EQ-Visual Analogue Scale (scale 0–100)[31 33]; Global Perceived Effect (GPE) on each of the WOSI subdomains (7-point scales, range: 'worse, an important worsening' to 'better, an important improvement').[12 15 34 35] A 1-year follow-up questionnaire was used to assess self-reported postintervention exercise, general practitioner (GP) visits, shoulder surgery, shoulder injury, painkiller consumption, adverse events and treatment utilisation. We used simple global dichotomised questions on Patient Acceptable Symptom State (PASS) and treatment failure to evaluate patient satisfaction with their current symptoms, and the Self-Efficacy Questionnaire with a 7-point ordinal scale. For PASS the participants were asked: 'When you think of your shoulder function, will you consider your current condition as satisfactory? By shoulder function, you should consider your activities of daily living, sport and recreational activities, your pain and other symptoms, and your quality of life', with the answer marked by either 'yes' or 'no'. Participants who answered 'no' were asked to complete the second single-item question, relating to treatment failure: 'Would you consider your current state as being so unsatisfactory that you think treatment has failed?', with the answer marked by 'yes' or 'no'.

We assessed self-efficacy related to symptoms, which can be defined as an individual's confidence to successfully produce desirable results related to living with symptoms. The Self-Efficacy Questionnaire has 10 items which are rated on a 7-point ordinal scale (ranging from 0 'not at all confident' to 6 'completely confident'). The questionnaire is applicable to patients with persistent pain and covers a range of functions including work, socialising and household chores as well as coping with pain without medication. The maximum score is 60, and the higher the score, the higher the level of self-confidence managing their symptoms.

Sample size

The power of the trial was set to 90% to detect a difference between the groups of at least 252 points (SD 350 points) at the 16-week follow-up based on previously reported studies on clinically important change.[36 37] A sample size of 42 per group was necessary, with a two-sided significance level of 0.05%, to detect a clinically important difference. We included 50 participants per group allowing a drop-out of 16%".[12 15] As the primary outcome was the same in this secondary analysis, the sample size was deemed sufficient for the purpose of comparing the between-group differences.

Statistical methods

Before any analysis commenced, a statistical analysis plan (osf.io/wftxe) was made publicly available. Descriptive analysis was

Table 3 Global Perceived Effect on WOSI subdomains, Patient Acceptable Symptom State (PASS) and treatment failure

	Total no of participants (LIGHT/HEAVY)*	LIGHT n (%)	HEAVY n (%)	Risk difference (95% CI)	P value
Physical symptoms†	42/44	18 (43)	24 (55)	12 (−9 to 33)	0.278
Sports/recreation/work†	42/44	15 (36)	23 (52)	17 (−4 to 37)	0.122
Lifestyle†	42/44	12 (29)	22 (50)	21 (1 to 42)	0.042
Emotions†	42/44	13 (31)	24 (55)	24 (3 to 44)	0.027
PASS	42/44	20 (48)	27 (61)	14 (−7 to 35)	0.201
Treatment failure	42/44	6 (14)	4 (9)	−5 (−19 to 8)	0.453

Data were analysed using the χ^2 test.
*Number of participants with data available at the 1-year follow-up.
†Improved: GPE score >5, rated as an important improvement.
GPE, Global Perceived Effect; HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise; WOSI, Western Ontario Shoulder Instability Index.

used to present the baseline characteristics with categorical data presented as a proportion (%), and continuous data presented as median (IQR) or mean (SD), as appropriate. Continuous outcomes were analysed using a linear mixed model analysis of repeated measurements, assuming missing at random based on the variables included in the model. Group, time (categorical scale: baseline, 16 weeks and 1 year) and the interaction term group×time and location were set as fixed effects and patient ID as random effect, adjusted for baseline value of the outcome of interest and site. The random-effect term was normally distributed. We also performed an analysis with the first follow-up visit coded as zero to show the between-group difference from postintervention to 1-year follow-up. No imputation was performed, as the linear mixed model analysis included all patients. Categorical outcomes were analysed with the χ^2 test or Fisher's exact test, and the risk difference with 95% CI was estimated. GPE was dichotomised using score >5 (rated as an important or very important improvement) as cut-point. As secondary analyses, all analyses were repeated for the per-protocol (PP) population—for both groups defined as those

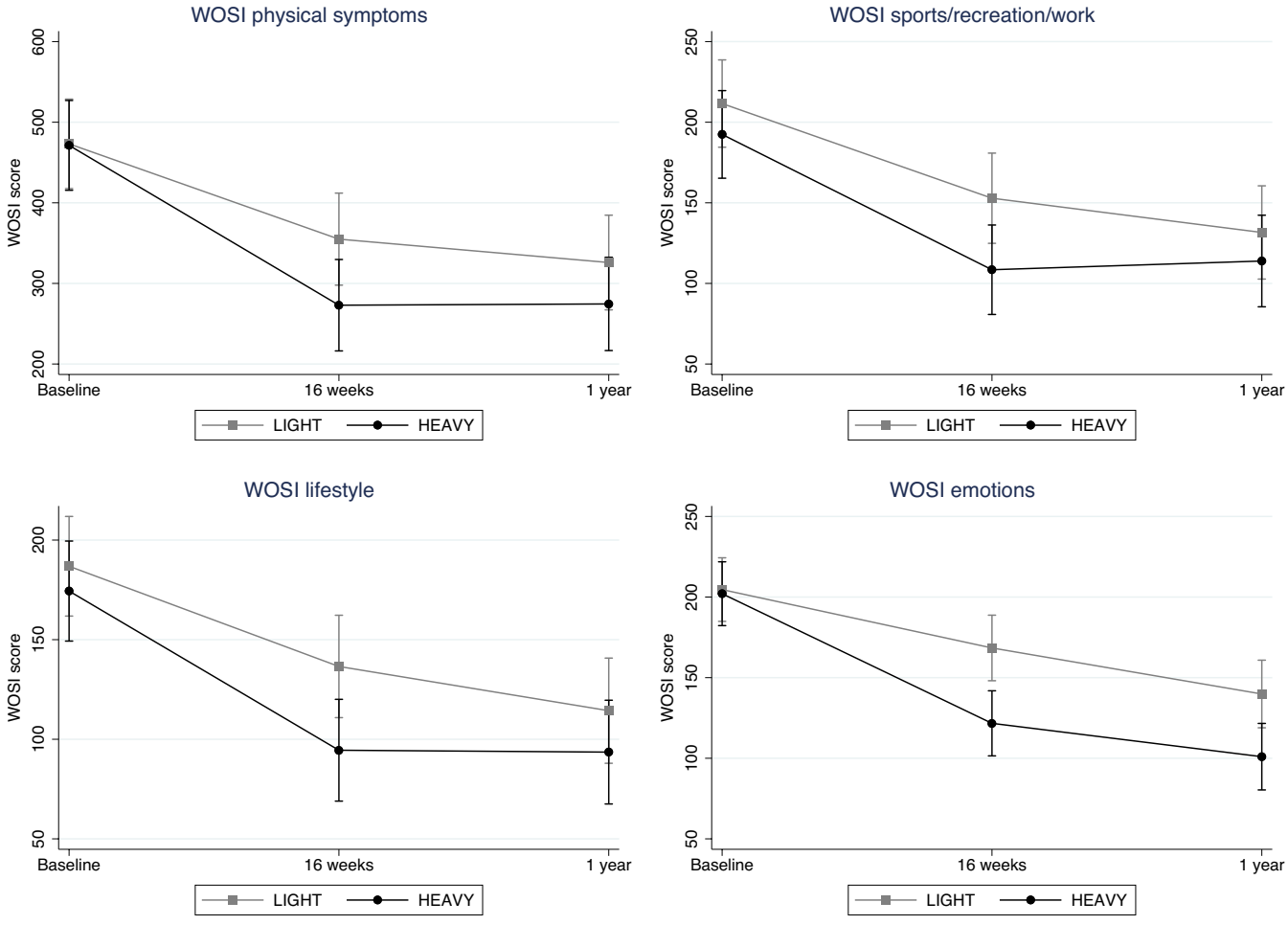

Figure 4 Western Ontario Shoulder Instability Index (WOSI) subdomain scores at baseline, 16 weeks and 1 year. The graphs illustrate the results from the primary analysis, with data points representing means and error bars indicating 95% CIs. HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise.

Table 4 One-year follow-up questionnaire regarding training, GP visits, operations, injuries, treatment, painkiller consumption and adverse events 8 months postintervention

	Total no of participants (LIGHT/HEAVY)*	LIGHT n (%)	HEAVY n (%)	Risk difference % (95% CI)	P value
Continued training	42/44	23 (55)	16 (36)	−18 (−39 to 2)	0.087
GP visits	42/44	11 (26)	5 (11)	−15 (−31 to 1)	0.077
Orthopaedic surgeon visits	42/44	6 (14)	4 (9)	−5 (−19 to 8)	0.516
Shoulder injury	42/44	0 (0)	1 (2)	2 (−2 to 7)	1.000
Shoulder dislocation	42/44	1 (2)	3 (7)	4 (−4 to 13)	0.616
Shoulder treatment	42/44	15 (36)	16 (36)	1 (−20 to 21)	0.950
Painkiller consumption	42/44	19 (45)	17 (39)	−7 (−27 to 14)	0.535
Adverse events	42/44	5 (12)	8 (18)	6 (−9 to 21)	0.417

Data were analysed using the χ^2 or Fisher's exact test.
*Number of participants with data available at the 1-year follow-up.
GP, general practitioner; HEAVY, high-load strengthening exercise; LIGHT, low-load strengthening exercise.

attending at least 32 (67%) of the 48 planned exercise sessions, completing the follow-up testing and not receiving steroid injections or surgery. For the statistical analyses, Stata V.17 was used.

Public and patient involvement

Patients (n=12) from our feasibility study were involved in the trial design by providing feedback on the outcome measures and exercise programme, as described previously.[38] No members of the public or patients were involved in the conduct or interpretation of this trial.

Deviations from the registered trial protocol

There were no deviations from our published protocol or the statistical analysis plan of the 1-year report.[15]

Equity, diversity and inclusion statement

Our research team included two women and six men. One author is Persian, and the rest are Scandinavians. We include authors at a variety of career stages and clinical disciplines. We do not present data on race, socioeconomic status or other social determinants, thus hindering an evaluation of the applicability of the findings according to these characteristics.

RESULTS

Out of 279 people who underwent eligibility testing, 100 were randomised (figure 1). The main reason for exclusion was not meeting the joint hypermobility criteria.[12] Out of 100 participants, 86 completed the 1-year follow-up assessment (LIGHT 84%, HEAVY 88%). The total number of non-adherent participants was 34; therefore, 66 participants (LIGHT 64%, HEAVY 68%) were included in the PP analysis.

At baseline, the groups were comparable (table 1). Patients were on average 37.8 years and mostly female (79%) with a mean Beighton score of 5.8. The mean WOSI-total score among participants was 1056.8 (SD 366.1).

Primary outcome

The analysis showed that both groups improved in WOSI-total score from baseline to 1 year (HEAVY −456.9, 95% CI −572.2 to −341.7; LIGHT, −364.0, 95% CI −481.4 to −246.6).

There were no between-group differences at 1 year either when looking at the change in the WOSI score from baseline to 1 year (−92.9; 95% CI −257.4 to 71.5) (table 2, figure 2), nor from postintervention at 16 weeks to 1 year (84.2; 95% CI −56.1 to 224.5). In HEAVY, 64% of the participants had a clinically important improvement in WOSI-total score at 1 year compared with 60% in LIGHT (figure 3). The results of the PP analysis were like the intention-to-treat (ITT) analysis with a larger but not statistically significant improvement in the mean difference in WOSI-total score favouring HEAVY (−144.3; 95% CI −321.6 to 32.9) (online supplemental file 1).

Secondary outcomes

There was a between-group difference in favour of HEAVY in WOSI-emotions (−36.3; 95% CI −65.4 to −7.3), GPE-emotions as 55% in HEAVY improved vs 31% in LIGHT (difference 24%; 95% CI 3% to 44%) and GPE-lifestyle as 50% in HEAVY improved vs 29% in LIGHT (difference 21%; 95% CI 1% to 42%) (tables 2,3, figure 4). In general, results slightly favoured HEAVY, but the secondary outcomes had large confidence intervals (tables 2–4, tables 1-2 in online supplemental file 1). Both groups were comparable in terms of healthcare utilisation, subsequent shoulder injuries or dislocations, painkiller consumption or adverse events (table 4, table 2 in online supplemental file 1).

DISCUSSION

HEAVY was not superior to LIGHT on self-reported shoulder function at 1-year follow-up. Most secondary outcomes confirmed the primary outcome, but HEAVY improved more than LIGHT in the WOSI subdomains 'emotions' and 'lifestyle', and the participants were more likely to score emotional benefits as important.

The 16-week report of HEAVY compared with LIGHT showed a statistically significant difference in self-reported shoulder function favouring HEAVY,[12] but although the effects in HEAVY and LIGHT were largely maintained at the 1-year follow-up with clinically important changes in both groups, there was no between-group difference. Interestingly, a larger proportion of patients in LIGHT continued shoulder-specific exercises postintervention (difference 19%; 95% CI −1 to 40%). Similar studies have shown the tendency of a greater improvement at short-term follow-up using exercise therapy, which is maintained at long term without further improvements after the end of intervention.[17 39–41] Acknowledging the fact that patients with HSD and shoulder symptoms have different clinical profiles (eg, regarding symptoms and coexistent shoulder diagnoses),[25] the difference in exercise programmes may be of importance when choosing which exercises the patient should use. There is moderate evidence for altered muscle activity and altered humeral and scapular kinematics in individuals with multidirectional instability with and without HSD that could be addressed in the rehabilitation.[42 43] Closed kinetic chain shoulder abduction exercises may enable full range of motion earlier in rehabilitation programmes, and open kinetic chain shoulder abduction exercises are required to facilitate the stabilising role of the rotator cuff and axioscapular muscles through daily function.[44] As such, closed kinetic chain and open kinetic

chain seem to facilitate different physiological mehcanisms and yet be effective to improve shoulder function at short-term[45 46] that is maintained at 1-year follow-up.

The minimal important difference (MID) for the WOSI-total score was a priori defined as 252 points (12%). Neither the ITT nor PP analysis met the defined MID (ITT 4.3%; PP 6.9%) at 1-year follow-up, meaning that the between-group differences are not clinically important. Out of 86 participants, 53 (62%) had a clinically important improvement in WOSI-total score from baseline to 1-year follow-up, with no difference between LIGHT and HEAVY. In both groups, the proportion of a clinically important improvement was above 60%, indicating that both interventions may improve self-reported shoulder function in more than half of the patients with hypermobile shoulders. This is comparable to subacromial impingement syndrome, where conservative treatment yields satisfactory results in 60% of cases within 2 years,[47] and 50% of patients with shoulder tendinitis recovering within 10 months.[48] Our findings add value to the current practice and urges the importance for clinicians to identifying patients with shoulder pain that fulfil the criteria for HSD in order to initiate exercise-based treatment.

The observed mean difference (12.4%) in the WOSI subdomain 'emotions' in favour of HEAVY was above the threshold of clinical relevance (12%). Although the CIs were wide (ie, 3% to 22%), our findings provide initial data to suggest that patients undergoing high-load strengthening exercise are slightly more positively 'conscious of their shoulder', 'less worried about worsening their shoulder problem' and 'less frustrated about their shoulder' than the LIGHT group. This is further supported by the results of GPE where a larger proportion (53% in HEAVY compared with 30% in LIGHT) of the participants allocated to HEAVY rated an important improvement on the subdomains 'emotions' and 'lifestyle'. We hypothesise that when patients experience success by being able to resume daily activities, they previously had problems with, they develop self-confidence and probably also better compliance to exercise.[49 50] This may lead to better function, mental state and increased patient satisfaction. In addition, the HEAVY exercises are more functional compared with LIGHT exercises and may faster transfer to everyday life and activities giving patients a better awareness of their shoulders. Furthermore, the integration of open kinetic chain exercises in shoulder rehabilitation may increase axioscapular muscle recruitment.[51] Therefore, HEAVY may potentially provide better shoulder awareness and less concern in patients with hypermobile shoulders compared with low-load strengthening exercise, but in turn it may require more effort and more frequent healthcare interactions, potentially resulting in reduced cost-effectiveness. Data on patient self-efficacy did not support better improvement favouring HEAVY, which may be because the self-efficacy questionnaire is not shoulder-specific and less responsive to the specific shoulder treatment provided in our study. Also, due to multiple testing, the significant result on the WOSI subdomain may be a spurious finding, and therefore, more robust data are needed to confirm these observations and their clinical implications.

This trial has some limitations. The CIs of the WOSI-total score between-group differences are large (ITT 95% CI −257.4 to 71.5; PP 95% CI −321.6 to 32.9), meaning that patients may respond differently on high-load or low-load strengthening exercise. The power was set to 90% with an expected drop-out of 16%, leaving 42 participants in each group.[12 15] At the 1-year follow-up, the drop-out rate was 14% with 42 participants in LIGHT and 44 in HEAVY, meeting the a priori requirements. This indicates that the study was sufficiently powered for the primary outcome, but the difference in patient response was smaller than expected.[52]

Blinding of the physiotherapists was not possible, which could have led to care provider bias if the treating physiotherapists favoured one intervention over the other. Blinding of the participants was not possible but both interventions were presented as having a potential effect. Furthermore, the number of planned supervised sessions differed between LIGHT and HEAVY (3 vs 32), which could lead to attention bias. The difference in received supervised sessions may compromise the results of WOSI-emotions because patients in HEAVY were able to confer with the treating physiotherapist, who could provide reassurance important for a more positive impact.[53] Lastly, we want to highlight the potential risk of selection bias in the PP analysis.

Strengths of the trial include that we preregistered a statistical analysis plan and performed the analyses blinded. Our assumption that loss to follow-up was missing at random seemed reasonable, since patients were similar on age, sex and baseline WOSI score. Furthermore, the generalisability of the findings of this trial is improved by the fact that participants were recruited from primary care, the choice of using standard care as a comparator, and the broad and accepted inclusion criteria for HSD.

CONCLUSION

At 1 year, there was no between-group difference in high-load versus low-load strengthening exercise on self-reported shoulder function in patients with HSD and persistent shoulder symptoms. Both exercise groups had reached clinically meaningful improvement and both interventions seem to be viable treatment options to improve shoulder function. Furthermore, high-load strengthening may have the potential to further improve shoulder-related emotions and lifestyle in patients with hypermobile shoulders at long term, but more robust data are needed to confirm these findings.

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Contributors BL and BJ-K conceived the study idea. All authors initiated the study design. BL, BJ-K, STS and JS helped with the implementation. BL, BJ-K, STS and CBJ provided statistical expertise in the study design and planning of the long-term analyses. DAF and EOC conducted the blinded analyses. BL, BJ-K, STS and KS contributed to the design of the study intervention. BL was the grant holder and principal investigator and responsible for patient inclusion and data collection. BL trained the study personnel in testing procedures. BL drafted this paper, and all authors have been involved in drafting versions and critically revising it for

important intellectual content and have read and approved the final version. BL is the guarantor of the study.

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