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ORIGINAL ARTICLE

Internet-based treatment for adolescents with symptomatic temporomandibular joint disc displacement with reduction. A randomized controlled clinical trial

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ABSTRACT

Objective: To evaluate treatment outcome of a jaw exercise (JE) intervention program combined with an information/counselling program (IC) vs. information/counselling alone.

Materials and methods: A clinical sample of 83 adolescents, experiencing painful clicking or catching/locking of the jaw, and diagnosed with symptomatic disc displacement with reduction according to RDC/TMD, were randomly assigned to JE/IC or IC program. Both programs were internet-delivered. The adolescents were examined clinically at baseline, at a 2-month mid-evaluation, and at 4months posttreatment by examiners blinded to which programs the adolescents were assigned to.

Results: The JE/IC group showed significantly more improvements of painful catching/locking ($p = .017$), eating ability ($p = .006$) and of their jaw function limitation ($p = .026$) compared to the IC group. Significantly more adolescents in the JE/IC group also reported a $\geq$50% improvement of the catching/locking of the jaw with pain ($p = .024$) and for eating ability ($p = .034$) based on a severity index. Treatment method credibility and satisfaction were also significantly higher in the JE/IC group.

Conclusion: The internet-delivered JE/IC program showed a better outcome compared to IC alone. The former is thus a feasible and cost-effective treatment for adolescents with symptomatic disc displacement with reduction.

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Introduction

Temporomandibular disorder (TMD) is a common condition characterized by pain and dysfunction related to the temporomandibular joints (TMJs) and/or masticatory muscles, and limitation in jaw function [1]. One of the most frequent disturbances to, and a common cause for, impaired jaw function is symptomatic TMJ disc displacement with reduction (DDR). The condition involves clicking, catching, and intermittent locking, and is also often associated with pain in the TMJ [2].

In epidemiological studies, the overall prevalence rates of TMD pain in adolescents range from 4 to 7% [3,4]. Approximately 17–30% of teens with frequent TMD pain are diagnosed with DDR, the condition being more common among girls than in boys [3,5]. In a general population-based study, the cross-sectional prevalence of DDR was found to increase with age during childhood and adolescence and to stabilize into adulthood [6]. In longitudinal studies, it has been reported that signs and symptoms of TMJ clicking and pain in adolescents fluctuate over time, but that they rarely worsen and may, in some cases, spontaneously disappear [5,7–9].

Symptomatic DDR may have a significant impact on young individuals. In a qualitative study, adolescents reported that TMJ catching and intermittent locking can lead to discomfort and pain associated with basic functions such as eating, chewing, and speaking and can adversely affect social relationships and reduce the adolescents' quality of life [10]. Relaxing and learning how to handle the jaws were self-care management strategies used among young people to deal with the jaw problem, while continued and increasing jaw pain was the main reason for seeking professional help [11].

It is estimated that approximately 50% of adolescents with frequent TMD pain want treatment [3,5]. In dental clinics, counselling, and jaw exercises (JEs), besides the use of occlusal appliances, have been found to be the most commonly used treatment methods for coping with TMD, among adolescents [12]. Results from clinical research have shown that the majority of teenagers respond well to conservative treatment with an occlusal appliance for TMD pain, from both a short and long-term perspective [13–15]. To our knowledge, no study has yet evaluated the effects of JE treatment with a focus on symptomatic DDR in adolescents. Previous trials evaluating JE in adult patients with symptomatic DDR have reported a reduction of both TMJ clicking and pain, as well as improved jaw function and global improvement [16–19].

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The use of information technology for intervention delivery has the advantage and potential to provide treatment to many individuals at a relatively low cost and with the low involvement of therapists. A recent systematic review and meta-analysis evaluated the effects of cognitive behavioural therapy adopted to an internet-delivered format for the treatment of recurrent headaches and chronic pain conditions in children and adolescents, suggesting that internet technology can be a useful intervention approach [20].

The aim of the present study was to evaluate treatment outcome effects of a JE program combined with information/counselling (IC), vs. the IC program alone, both programs internet-delivered for adolescents with symptomatic DDR. We hypothesized that adolescents receiving the combined JE/IC program would have a better outcome in terms of intensity and frequency of TMJ symptoms and related pain, as well as eating ability, anxious/depressive and somatic problems, global improvement, and clinical signs, compared to adolescents receiving the IC program alone.

Material and methods

Participants

The study was conducted between January 2012 and June 2017 and included adolescents referred to the Department of Stomatognathic Physiology, Public Dental Health Service, in three Swedish cities, Kalmar, Linköping, and Norrköping. A total of 738 adolescents were assessed, of whom 101 met our inclusion criteria and were invited to participate in the study. Eighteen patients declined to participate, mainly due to lack of interest, and distance and/or transportation problems, leaving 83 participants who were allocated to either treatment arm (Figure 1).

The following inclusion criteria were used: (1) age 12–19 years; (2) experiencing painful clicking or painful catching/locking at least once a week for at least 3 months; (3) a diagnosis of DDR, according to the Research Diagnostic Criteria for TMD (RDC/TMD) [21]; and (4) wanting treatment. Patients with juvenile idiopathic arthritis, migraine, or ongoing orthodontic treatment were excluded.

All patients and their parents received both verbal and written information about the study. They were informed that transient pain in the jaw muscles or jaw joints could occur during the training intervention. Patients who were 18 years or older signed a written consent form for participation; for younger patients ($n = 56$), the consent form was signed by the parents. The patients and their parents were assured that the patients could cancel their participation in the study at any time without this affecting their continued clinical care.

The study was approved by the Regional Ethics Committee of the Faculty of Health Sciences at Linköping University (Ref No. 2011/309-31).

Randomization and trial design

Randomization was performed before the study, using random numbers generated in SPSS 20.0 [22], and included all three study centres for the allocation sequence to intervention with either (1) IC, or (2) JE/IC. An assistant not otherwise involved in the study placed the assignments in consecutively numbered, sealed opaque envelopes, to be distributed to each centre and research team.

All patients who agreed to participate in the study and met the inclusion criteria received a personal login code to a web-based platform depending on their allocation to either intervention and valid throughout the study. For all participants, the platform included baseline and follow-up questionnaires, and a PowerPoint presentation with information/counselling on TMD.

At baseline, a dental nurse instructed the participants on how to use the platform. The patients filled out the questionnaire and watched the PowerPoint presentation. Participants in the JE/IC group also had access to 5 min long instructional film with specific JEs on their platform, and practiced JEs through mirrored exercise when watching the instructional film (see 'Treatment' below). A dental nurse was available to answer questions if needed. In both treatment groups, the adolescents had access to the information material, and for the JE/IC group, the instructional film was also available throughout the treatment period. All patients had the option, throughout the study, to use the platform to ask questions or communicate with the research team at their respective trial clinics.

After 2 weeks, all participants were invited to a clinic visit, or, for those who had a long way to travel to the clinic, were contacted by phone by a dental nurse in the respective research teams, for adherence monitoring and continued motivation for treatment. In both treatment groups, the patients were evaluated before treatment (baseline), after 2 months (mid-evaluation), and 4 months after treatment initiation (posttreatment). At each evaluation, all participants filled out a questionnaire on the platform, and a clinical examination was performed at each study site by calibrated TMD specialists (A.D.C., I.M.N., K.W.), all blinded to treatment allocation. The total time used by the dental nurse in the study at baseline and the two check-up evaluations added up to approximately 1 h and 15 min per patient and was roughly equal in length between the two groups.

Assessment

The clinical examination was performed in accordance with RDC/TMD examination guidelines [21] and involved TMD pain sites, mandibular movement capacity (mm) and associated pain, presence of TMJ sounds, and pain upon palpation of the TMJs and jaw muscles. This procedure allows for establishing the following multiple diagnoses: myofascial pain, disc displacement, and/or arthralgia/arthrosis [21]. Acceptable reliability has previously been reported for the clinical examination and diagnoses [23].

The questionnaires evaluated intensity and frequency of TMJ symptoms and related pain; eating ability; jaw function limitation; general health (assessed at baseline with the following categories: 'Excellent', 'Very good', 'Good', 'Fairly good' and 'Bad'); emotional and somatic complaints; treatment motivation and credibility; adherence to, and satisfaction with, treatment; and the patient's impression of global improvement.

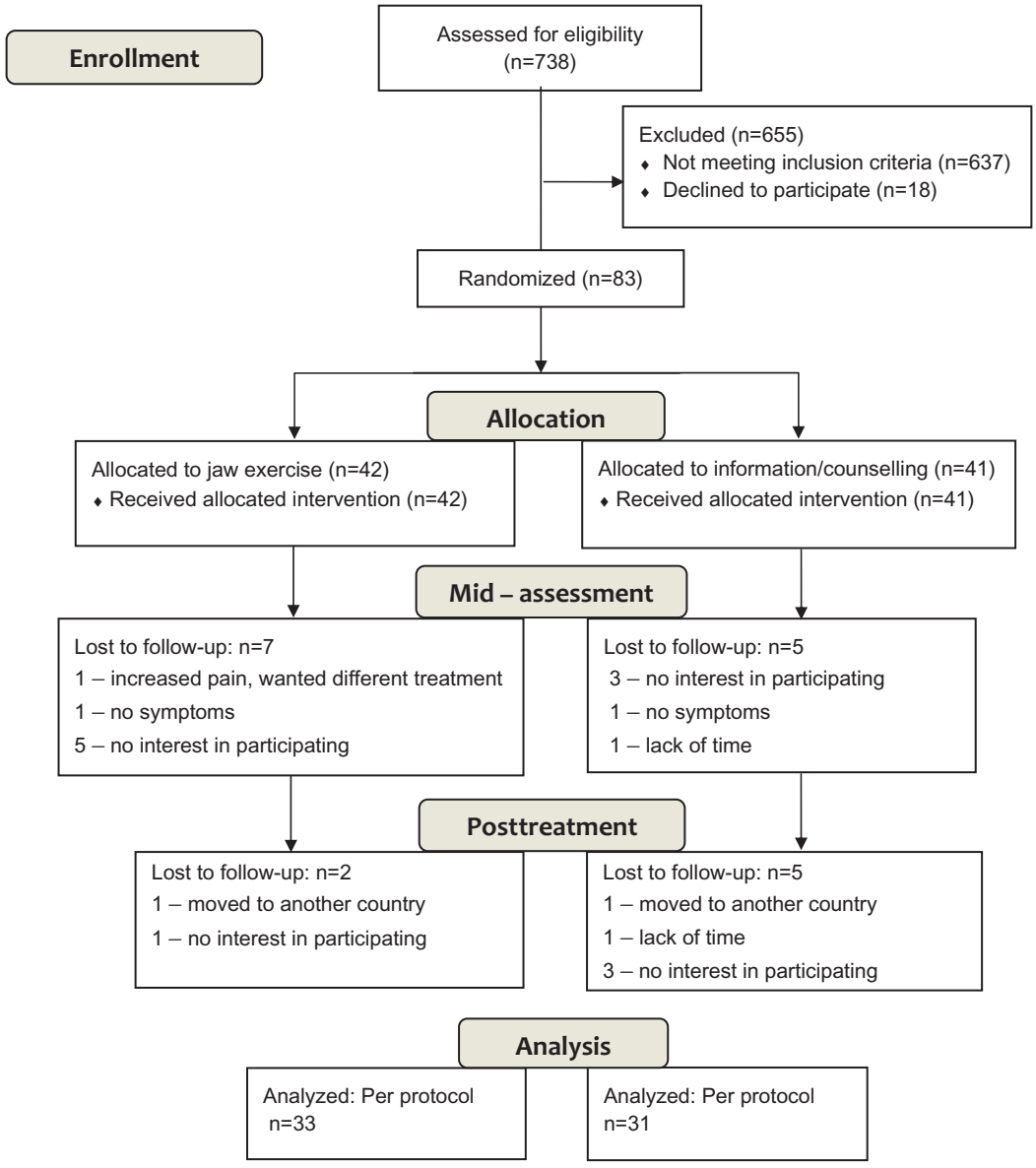

Figure 1. Flowchart of participants in the study.

Outcome assessment

The frequency and intensity of the presenting TMJ symptoms were our two primary outcome measures and were assessed at baseline, and mid and posttreatment:

- The *frequency* of TMJ clicking and TMJ catching/locking, with pain, was reported on a 5-point scale, where 1 = 'Never', 2 = 'One to two times a month', 3 = 'Once a week', 4 = 'Several times a week' and 5 = 'Daily'.
- The *intensity* of TMJ clicking and also of TMJ catching/locking, with pain, was reported on an 11-point numeric rating scale (NRS), with 0 = 'No pain' and 10 = 'Worst pain imaginable' as endpoints.

The following secondary measures were also assessed:

- *Eating ability* (chewing, swallowing, or taking a large bite) was reported on the same 5-point scale as above and the intensity of eating problems was rated on a 0–10 NRS with the endpoints 0 = 'No trouble' and 10 = 'Worst trouble imaginable'.
- *Symptom severity index (SSI)*. Changes in symptom severity scores between baseline and posttreatment were also estimated on the three outcome variables above using an index calculated as a product of symptom intensity and frequency (total range 0–50). An improvement of 50% or more was considered to reflect a clinically significant improvement [13,24].
- *Global improvement*. The Patient Global Impression of Change (PGIC) scale was used to assess patients' self-perceived improvement regarding TMJ clicking, catching/locking and associated pain, and ability to eat in response to treatment. The PGIC is a 7-point scale with response categories ranging from 'Completely well/Very much improved' to 'Very much worse'. The response categories: 'Completely well/Very much improved', 'Much improved', and 'Somewhat improved' were here considered to represent the response to treatment; while participants

reporting 'No change', 'Somewhat worse', 'Much worse', and 'Very much worse' were considered non-responders [24].

- *Anxious/depressed and somatic complaints.* These two subscales, included in the Youth Self-Report, were used to assess anxiety and depression problems (14 items; score range 0–28), and somatic complaints (nine items; score range 0–18) [25,26] during the past 6 months. The items were rated on a 3-point scale, where 0 = 'Not true', 1 = 'Somewhat or sometimes true' and 2 = 'Very true or often true'.
- *Jaw functional impairment*. The eight-item Jaw Functional Limitation Scale (JFLS-8) rated limitation for the last month on a 0–10 NRS with the endpoints 0 = 'No limitation' and 10 = 'Severe limitation' (total score range 0–80). The items were the ability to: 'Chew tough food', 'Chew chicken', 'Eat soft food', 'Open the mouth wide enough to drink from a cup', 'Swallow', 'Yawn', 'Talk' and 'Smile' [27].
- *Maximum jaw opening, and jaw opening without pain and without TMJ clicking*. The distance was measured in millimetres with a ruler between the maxillary and mandibular central incisors, adding the vertical overbite [23].

Treatment credibility and motivation

After watching the PowerPoint presentation, in both groups, and the instruction film, in the JE/IC group, the adolescents were asked to rate the following questions on an 11-point scale: (1) 'How good do you think this treatment method is for your painful clicking/catching/locking?' Endpoints were: 0 = 'Not good at all' and 10 = 'Very good'. (2) 'Would you recommend this treatment to a friend with the same type of painful clicking/catching/locking problem as you have?', with endpoints being 0 = 'Not at all' and 10 = 'Absolutely'. (3) 'How motivated are you to begin this treatment?', with the following endpoints: 0 = 'Not at all' and 10 = 'Very much'. (4) 'How much time and work are you willing to put into this treatment?', with endpoints: 0 = 'Very little' and 10 = 'Very much', and, (5) 'How well did you understand the information/counselling program?', with endpoints: 0 = 'Not at all' and 10 = 'Completely'.

Treatment

Jaw exercise

This treatment approach aims to develop and maintain normal muscle and joint function and stability, affect disc/TMJ relation by altering the loading conditions, and reduce joint clicking and pain [28]. Jaw exercise included four jaw movement sequences, performed without evoking joint clicking, as follows: (1) jaw opening; (2) moving the jaw to the left and (3) to the right; and (4) moving the jaw towards the protrusive position.

The adolescents were instructed *via* the instructional film to begin the exercises by stretching the neck and pulling in the chin slightly, release dental contact, and then perform the jaw movements against a constant moderate resistance applied by their thumbs under the chin for jaw opening and three fingers against the chin for the other movements. They were instructed to hold the pressure against the chin for 6 s, then release the pressure and repeat each movement sequence six times. They were encouraged to practice the JE at least three times a day until the first evaluation, at 2 months, and, if needed or recommended, also to continue their training until the 4-month posttreatment assessment.

Information/counselling

The IC program contained information on TMJ-related anatomy, TMJ function/dysfunction, TMD epidemiology, parafunction and stress, as well as advice not to provoke the symptoms.

Treatment adherence. At the two evaluation points, patients in the JE/IC group were asked to rate the frequency of JEs during the last 4 weeks on a 5-point scale, where 1 = 'Daily', 2 = 'Several times a week', 3 = 'Once or twice a week', 4 = 'Occasionally' and 5 = 'Never'.

They also reported the reason for not having performed the JE, with the following answer options: 'Have no clicking/locking/pain', 'Lack of time', 'The exercises give me more trouble with clicking/locking/pain' and 'Other reasons' (reported in free text).

Treatment satisfaction. At the posttreatment evaluation, patients were asked to rate the treatment as a whole on a 5-point scale, where 1 = 'Very good', 2 = 'Pretty good', 3 = 'Neither good nor bad', 4 = 'Pretty bad' and 5 = 'Very bad'.

Sample size

Our power calculation was based on the results of a previous randomised controlled trial (RCT) and treatment of TMD among adolescents in a similar clinical sample [13]. With an expected proportion of 25% of individuals in the IC group and 50% of the JE/IC group achieving a clinically significant improvement on our index outcome criterion of clicking or locking with pain, it was estimated that 58 participants were needed in each treatment group, with $\alpha = 0.05$ and $\beta = 0.80$, and an expected dropout rate of 20%.

Statistical methods

For descriptive statistics, median and quartiles (Q1–Q3) were reported, and for continuous variables means and standard deviation (SD). Associations between categorical variables were analyzed using Pearson's chi-square test, and the McNemar change test was used for testing paired differences with dichotomous variables. For changes across time on ordinal variables, the Friedman non-parametric test was used, and if significant followed by post hoc analyses with Wilcoxon matched pair test with Bonferroni corrections. Mann–Whitney *U* test was used to calculate differences between treatment groups and change scores at the three-time points. For continuous dependent variables, independent *t*-test, analysis of variance (ANOVA) or covariance

Table 1. Distribution of participants randomized to one of the two treatment groups, receiving either jaw exercise (JE) in combination with information/counselling (IC) (JE/IC) or IC, by gender, age, general health temporomandibular disorder diagnosis, treatment credibility, and having understood the information.

		Treatment group	
	All ($n = 83$)	JE/IC ($n = 42$)	IC ($n = 41$)
Gender, *n* (%)			
Girls	69 (83)	37 (88)	32 (78)
Boys	14 (17)	5 (12)	9 (22)
Age, years, mean (SD)	15.6 (2.1)	15.6 (2.1)	16.3 (2.1)
General health ($n = 82$), *n* (%)			
Excellent	27 (33)	15 (36)	12 (30)
Very good	24 (29)	14 (33)	10 (25)
Good	24 (29)	10 (24)	14 (35)
Fairly good	6 (7)	3 (7)	3 (8)
Bad	1 (1)	0 (0)	1 (2)
RDC/TMD, *n* (%)			
Disc displacement	83 (100)	43 (100)	40 (100)
Myofascial pain	69 (83)	37 (88)	32 (78)
Arthralgia	48 (58)	22 (52)	27 (66)
Treatment credibility, (NRS 0–10), mean (SD)			
Treatment method	7.3 (1.8)	7.8 (1.6)*	6.8 (1.8)
Would recommend it to a friend	8.0 (2.0)	8.0 (2.1)	7.9 (2.0)
Motivated to begin treatment	8.1 (2.1)	8.1 (2.4)	8.1 (1.9)
Willing to spend time on treatment	7.6 (2.1)	7.5 (2.2)	7.8 (2.0)
Understood the information, (NRS 0–10), mean (SD)	9.3 (1.3)	9.4 (1.4)	9.3 (1.2)

RDC/TMD: research diagnostic criteria for temporomandibular disorder; SD: standard deviation; NRS: numeric rating scale.
*$p < .05$.

(ANCOVA) was used to test for the difference between the groups or changes across time, giving between-group and interaction effects. Clinical significant improvement was here defined as at least a 50% pre-post improvement in a symptom severity index (SSI) (intensity × frequency) calculated as [(SSI baseline − SSI posttreatment/SSI baseline) × 100]. The efficacy of treatment was also estimated based on Number Needed to Treat (NNT) reflecting the number of patients needed to treat for one to benefit and represents the inverse of absolute risk reduction expressed as a decimal (of percentages for group 1 vs. group 2) [29]. A probability level of $p <$ .05 was considered statistically significant.

Results

A flow chart of the participants including the number of dropouts during the course of treatment, and reasons for dropping out, is presented in Figure 1. In total, 24% ($n = 10$) of the participants in the IC group and 21% ($n = 9$) in the JE/IC group dropped out before the posttreatment evaluation, with no significant difference between the treatment groups. Reasons for dropping out were mainly lack of interest and no time to participate in the study; one participant reported increased pain as a reason.

The results of per-protocol analysis are presented below. Table 1 presents baseline data on all subjects randomized to treatment. No significant differences in regard to gender, age, general health, and TMD diagnosis were found between the two treatment groups; nor were there significant differences between treatment completers and dropouts.

Treatment credibility and motivation

The participants in the two treatment groups were similarly motivated for treatment, but the adolescents in the JE/IC group considered their intervention as a significantly ($p =$ .012) more credible treatment compared to those assigned to IC alone. The patients in the two groups had understood the information given on the platform equally well (Table 1). There were no significant differences between dropouts and treatment completers.

Treatment outcome

Temporomandibular joint symptoms

The frequency and intensity of TMJ symptoms and pain, and eating ability did not differ significantly between the groups at baseline.

The frequency of TMJ symptoms and impairment of eating ability were found to decrease significantly over time in both treatment groups. Specifically, within-group differences between pre-mid and pre-posttreatment scores for painful catching/locking and eating ability were significant in the JE/IC group at both intervals but only significant between pre-mid points in the IC group. For TMJ painful catching/locking significantly ($p = .017$) higher pre-post change scores were found in the JE/IC group compared to the IC group (Table 2).

For intensity, the results of the ANCOVAs using baseline scores as covariates showed non-significant time effects for clicking and catching/locking with pain, [$F(1, 57) = 2.06$ and $F(1, 57) = 3.09$], between-group differences, [$F(1, 57) = 1.53$ and $F(1, 57) = 2.71$] or their interactions, [$F(1, 57) = 0.32$ and $F(1, 57) = 1.17$]. Similarly, for eating ability, a time by between-group interaction effect [$F(1, 57) = 3.41$], and main effects of time and between-group differences, the outcomes were non-significant, [$F(1, 57) = 0.06$ and $F(1, 57) = 2.72$, respectively] (Table 3).

Clinically significant improvement

The result of at least a 50% improvement in the three index (frequency by intensity) outcome dependent variables by

Table 2. Medians (Md) and quartiles (Q1–Q3) for frequency (scale 1–5) of temporomandibular joint (TMJ) symptoms before treatment (Pre) and at the 2-month (Mid) and 4-month (Post) evaluation, by treatment group.

	Treatment group				
	JE/IC ($n = 30$)		IC ($n = 30$)		Δ JE/IC vs. IC
	Md (Q1–Q3)	p^a	Md (Q1–Q3)	p^a	p^b
TMJ painful clicking					
Pre	4 (3–5)		4 (3–5)		
Mid	3 (2–4)	.001	3 (2–4)	.005	.584
Post	2.5 (1–3)	.010	3 (2–4)		.066
TMJ painful catching/locking					
Pre	3 (2–4)		3 (2–3)		
Mid	2 (2–4)	.004	2.5 (2–3)		.419
Post	1 (1–3)	.013	2 (1–3)		.017
Eating ability					
Pre	4.5 (3–5)		4.5 (3–5)		
Mid	3.5 (2–5)	.004	3 (2–5)	.002	.575
Post	2 (1–3)	.001	3 (2–4)		.077

Differences in raw and change scores between the treatment groups were estimated at the three assessment points.
IC: information/counselling; JE: jaw exercise; NRS: numeric rating scale.
[a]Overall differences within treatment groups over time were calculated with Friedman non-parametric test and, if significant, further explored with Wilcoxon signed rank test as post hoc test.
[b]Mann–Whitney *U* test was used to calculate differences in pre-mid and pre-post scores between treatment groups.

Table 3. Means (SDs) for intensity of temporomandibular joint symptoms, before treatment (Pre) and at the 2-month (Mid) and 4-month (Post) evaluation, and pre/post scores on the Jaw Function Limitation Scale (JFLS-8), and the anxious/depressive and somatic subscales of the Youth Self-Report, by treatment group.

	Treatment group					
	JE/IC			IC		
	Pre ($n = 42$)	Mid ($n = 34$)	Post ($n = 30$)	Pre ($n = 41$)	Mid ($n = 35$)	Post ($n = 31$)
TMJ painful clicking, NRS 0–10, mean (SD)	5.5 (2.5)	4.3 (2.5)	3.1 (2.9)	5.6 (2.3)	5.3 (2.7)	4.2 (2.7)
TMJ painful catching/locking, NRS 0–10, mean (SD)	5.8 (2.6)	3.8 (3.1)	2.5 (3.1)	5.8 (2.6)	5.1 (2.9)	3.9 (3.2)
Eating ability, NRS 0–10, mean (SD)	5.7 (2.3)	4.7 (2.7)	2.8 (2.7)	5.8 (2.2)	5.7 (2.1)	4.4 (2.9)
JFLS-8 (0–80), mean (SD)	31.8 (14.8)		21.1* (11.8)	30.6 (13.6)		27.3 (16.2)
Anxious/ depressive symptoms (0–18), mean (SD)	7.4 (1.1)		7.1 (1.0)	5.5 (1.1)		4.7 (1.0)
Somatic symptoms (0–28), mean (SD)	4.7 (0.6)		4.6 (0.79)	3.6 (0.6)		4.0 (0.7)

IC: information/counselling; JE: jaw exercise; NRS: numeric rating scale; SD: standard deviation.
*JE/IC vs. IC, $p < .05$.

treatment group showed the following outcomes: For catching/locking with pain, a significant association was found, χ^2 (1) = 5.12, $p = .024$, in that 67.9% of those treated with JE/IC achieved a 50% reduction in symptoms, compared to 37.4% of participants in the IC group. An almost identical outcome was obtained for improved eating ability, χ^2 (1) = 4.52, $p = .034$ (67.9 vs. 40%, respectively). The association between clicking with pain and treatment was not significant, χ^2 (1) = 3.27, $p = .07$ (63.3 vs.40%, respectively). Further analyses using the McNemar test showed significant changes, with participants achieving at least 50% improvement from the mid to the posttreatment evaluation, but only for the JE/IC group and for clicking with pain ($p = .021$) and eating ability ($p < .001$).

Results of further analyses showed that at least three to four patients need to be treated (NNT) for one to experience a 50% improvement or more on the index for catching/locking with pain or clicking with pain. The observed power for clicking with pain, catching/locking with pain, and reduced eating ability varied from 0.16 to 0.43, with effect sizes of 0.02–0.06 for the time by treatment group interaction effects.

The JFLS-8

The results of the ANOVA showed a significant between-treatment group effect, [$F(1, 57) = 5.60$, $p = .021$], with lower total sum scores in the JE/IC group and an effect size of 0.08 and an observed power of 0.61. Over time a significant main time effect with a decrease was also found, [$F(1, 58) = 19.06$, $p = .001$], with an ES of 0.25. The JE/IC treatment group showed a significantly stronger reduction in total JFLS scores over time compared to the IC group, with a significant interaction effect, [$F(1, 58) = 5.23$, $p = .026$] (Table 3).

Emotional and somatic problems

The results of the ANCOVAs using baseline scores as covariates, with no significant difference between treatment groups, showed a non-significant change at the posttreatment evaluation in the anxious/depressed and somatic subscales of the Youth Self-Report (Table 3).

The PGIC scale

While more participants in the JE/IC group, compared with the IC group, reported improvement regarding painful clicking (76.7 vs. 54.8%) and painful catching/locking (66.7 vs. 45.2%), the differences were non-significant. For eating ability, at posttreatment 76.7% of adolescents in the JE/IC group reported a positive response to the treatment, compared to 41.9% of those in the IC group who reported such

Table 4. Means (SDs) for maximal jaw opening, jaw opening without clicking, and jaw opening without pain, before treatment (Pre) and at the 2-month (Mid) and 4-month (Post) evaluation, by treatment group.

	Treatment group					
	JE/IC			IC		
	Pre ($n = 41$)	Mid ($n = 35$)	Post ($n = 33$)	Pre ($n = 40$)	Mid ($n = 36$)	Post ($n = 30$)
Maximal jaw opening (mm), mean (SD)	47.3 (7.4)	48.0 (7.5)	48.2 (8.2)	48.6 (5.2)	47.9 (6.2)	48.2 (8.3)
Jaw opening without clicking (mm), mean (SD)	26.4 (13.0)	34.8* (14.5)	33.3 (16.3)	26.0 (13.2)	26.3 (14.5)	26.8 (13.0)
Jaw opening without pain (mm), mean (SD)	34.4 (8.5)	35.7 (11.7)	39.3 (10.2)	38.2 (8.4)	35.5 (9.6)	39.0 (9.8)

IC: information/counselling; JE: jaw exercise; SD: standard deviation.
*JE/IC vs. IC, $p < .05$.

improvement level, a highly significant difference, χ^2 (1) = 7.60, $p = .006$.

Clinical measures

At the mid-treatment evaluation, a significant difference between treatment groups was found for jaw opening without clicking, [$F(1, 60) = 6.14$, $p = .016$], with participants in the JE/IC group increasing their opening more than those in the IC group, and this finding persisted also at posttreatment. The results of the ANCOVA showed a significant time effect for maximal jaw opening without pain, [$F(1, 60) = 4.47$, $p = .039$]. However, no significant time by treatment group interaction effect was found for maximal jaw opening capacity, jaw opening without pain, or jaw opening without clicking (Table 4).

Treatment adherence and response

Treatment adherence to jaw training was reported to be high among subjects in the JE/IC group who completed the 4-month treatment period, with 79% at mid-evaluation and 59% at posttreatment reporting training daily or several times a week. However, because of the limited number of participants in the JE/IC group who trained less frequently, no comparisons could be made on potential outcome differences with regard to frequency of training.

Reasons for poor patient adherence to JEs at posttreatment were reported by eleven participants. Eight reported a lack of time, forgetting to exercise, or no longer being motivated. Increased pain during JE was reported by three adolescents. None of the study participants used the opportunity to contact the research team for questions during the study period.

Treatment satisfaction

At posttreatment, significantly more participants in the JE/IC group, compared to the IC group, rated the treatment as 'Very good' or 'Pretty good', (80 vs. 52%, respectively), χ^2 (1) = 5.44, $p = .020$.

Discussion

This RCT compared the effects of two types of internet-based self-administered treatments for adolescents with symptomatic DDR. While the main results showed that both treatment programs had positive effects on symptom alleviation during the treatment period, overall the structured JE training program, combined with IC, had significantly stronger effects on adolescent-reported severity of TMJ symptoms compared to treatment with IC alone, with both treatment groups receiving the same amount of time for dental nurse assistance (1.25 h). We further noted that almost twice as many participants in the JE/IC group, compared to those allocated to IC, reported a subjective global clinical improvement on the PGIC scale in several of the TMJ symptoms.

Fundamental oral functions, such as eating, chewing, and speaking, can be adversely affected by painful clicking and catching/locking, which can be experienced as distressing by people with symptomatic DDR [10]. We found that regular JE provides a significantly greater improvement in eating ability and speaking as assessed by JFLS-8, compared to receiving only information and advice on oral behaviour. This suggests that jaw training can improve the quality of daily life of adolescents with symptomatic DDR. Various psychological problems, such as frustration, worries, bad mood, and ruminations about pain and TMJ dysfunction, have also been reported by youths with this condition [10]. Although the treatment in this study reduced TMJ symptoms, it did not reduce levels of anxious/depressive or somatic symptoms, which overall were largely within norms for this age group in Sweden [26].

In previous research, the outcome of JE therapy has been evaluated primarily in adult patients. Armijo-Olivo and coworkers [30], in their systematic review and meta-analysis, noted a positive treatment outcome of JEs for treatment of TMD, with few adverse effects; however, they emphasized the uncertainty about the overall effectiveness of exercise therapy for TMDs. In a recent RCT by Wänman & Marklund [19], the treatment outcome of a clinically based, supervised JE program, a home JE program, and occlusal splint therapy was evaluated in adult patients with symptomatic DDR. While both the JE programs and occlusal splint therapy had positive effects on TMJ clicking sounds, the supervised exercise program was found to be more effective in reducing TMD pain, compared to the other two treatment approaches.

Pain-free joint clicking sounds may be regarded as a harmless symptom, which rarely requires treatment; pain and dysfunction, on the other hand, reflect a stronger need for treatment [31]. One reason why adolescents with DDR seek professional care is that they want a well-grounded explanation for the origin of their jaw problem [11]. Since the course of TMJ symptoms and pain often fluctuates in frequency and severity, information about the condition and its prognosis, as well as advice to attempt to avoid stimuli and behaviour that can provoke the symptoms, should therefore

be considered as the first line of therapy and an important element of other supplementary treatment. Moreover, in TMD treatment, individual empowerment should always include strategies to diminish disturbing symptoms. This recommendation is further emphasized by the modest outcome in the present IC group, in which over 40% of the adolescents reported an improvement in TMJ symptoms posttreatment.

One important purpose of the present internet-based treatment was to develop and provide adolescents with a guided and structured low-cost program that addresses their pain-related jaw problems with minimal therapist support. Such a strategy has been successfully used by others, including email or telephone contacts to maintain efficacy and adherence, in the treatment of recurrent headaches in adolescents [32,33].

A problem in internet-based studies is that attrition rates have varied strongly and have sometimes been very high [34]. In the present study, the total dropout rate was modest (23%). While a supplementary chat for communication with a therapist may contribute to keeping adolescents in a controlled study [35], Spek and colleagues [36] noted that using a chat maybe cost-ineffective as the therapist might be required for an extended period of time during the course of a study. Several investigators have further underlined the importance of therapist support in internet-based interventions [34,36]. The participants in our internet-based study had the opportunity to communicate with the research team *via* the internet platform if they had questions. Although they did not make use of this opportunity, the ability to do so may have positively influenced the adherence and dropout rate

Jaw exercise several times a day is important for achieving optimal effects on TMD pain and function in adults, according to Michelotti and collaborators [37]. In the present study, the majority of adolescents in the JE/IC group reported good adherence to treatment, and the results at posttreatment also support the importance of the use of regular, frequent JE. The endurance and adherence to the JE protocol may therefore be an important aspect that should be emphasized to adolescents prior to treatment to achieve an optimal outcome. Performing the exercises in conjunction with already established routines, and in privacy, are other factors suggested to enhance adherence to treatment [38]. Psychological distress, poor social support, and increased pain levels during exercise have been identified as barriers associated with poor treatment performance in adults [39]. In the present study, three adolescents reported increased pain during exercise as a reason for not performing JEs.

The strengths of the present study are the use of a standardized and structured internet-delivered program which reduced the amount of effort and expert assistance needed in treatment provision; also, the dropout rate was reasonable. The study used most of the recommended outcome criteria outlined by The Paediatric Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (PedIMMPACT) [40], including numeric rating scales, measurement of physical and emotional functioning, adverse events, and patient's global impression of change, together with detailed information on participant recruitment and progress through the trial.

However, in the interpretation of our findings, it should be noted that participants in the IC group considered information and counselling as a less credible treatment, and they were also less satisfied with the treatment compared to those receiving JE. Both these aspects are likely to have contributed to a more positive outcome in the latter group. The positive effects in both treatment groups may also reflect the influence of unspecific factors related to the reception of the treatment itself and the clinical assessment; they could also reflect spontaneous remission over the relatively short treatment period.

A weakness in the present study is the limited sample size, which was smaller than planned and which also lowered the statistical power in our analysis. Still, our outcomes showed clinically important differences between the treatment groups and magnitudes in important functioning areas, in favour of the active training program.

Conclusion

The overall results indicate that a JE program combined with IC, internet-delivered, may be a feasible and cost-effective treatment, with a low risk of adverse effects. The results also show that this is a more effective treatment of TMJ symptoms, compared to the provision of IC for TMJ symptoms alone, in adolescents with symptomatic DDR. In future research, the effects of e-health in the treatment of adolescents with TMD pain and TMJ dysfunction should be further evaluated in a larger clinical sample, and an attempt should be made to identify characteristics of those who benefit from such a treatment approach, as well as those who need more extensive therapeutic support.

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