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Posture Awareness Intervention for Musculoskeletal Prevention in High School Students: Effects on Body Awareness and Muscle Endurance

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Abstract

Background

Early prevention of musculoskeletal problems is important during adolescence, when prolonged sitting, physical inactivity, and postural habits may contribute to later musculoskeletal complaints. School-based posture training usually focuses on strengthening and stretching exercises, while less attention is given to the repeated recall and conscious application of correct posture in everyday routines. This study examined the effects of a 7-week school-based posture awareness intervention on body awareness, posture-related muscle endurance, and self-reported posture monitoring among high school students.

Methods

A quasi-experimental pretest and posttest control group design was used. The study involved 182 high school students from three secondary schools in Budapest, Hungary. The Posture Group included 77 students, and the Control Group included 105 students. Both groups received introductory posture education and followed the standard physical education curriculum. The Posture Group additionally received weekly functional posture training, strengthening and stretching exercises, daily posture-control reminders, and teacher reinforcement. Body awareness was assessed using the Hungarian version of the Body Awareness Questionnaire. Back and abdominal muscle endurance were measured using holding-position tests. Analysis of covariance was used to examine group effects after adjusting for baseline values.

Results

Students in the Posture Group reported daily posture monitoring more frequently than students in the Control Group, $\chi^2(1) = 43.718$, $p < .001$. After adjustment for baseline values, significant group effects were found for back muscle endurance, $F(1, 177) = 9.633$, $p = .002$, $\omega^2 = .033$, and body awareness, $F(1, 179) = 8.804$, $p = .003$, $\omega^2 = .019$. No significant adjusted group effect was found for abdominal muscle endurance, $F(1, 179) = 0.025$, $p = .874$, $\omega^2 = .000$.

Conclusions

The findings suggest that a short school-based posture awareness intervention may support body awareness and back muscle endurance among high school students. Regular reminders and teacher reinforcement may be feasible elements of adolescent musculoskeletal prevention in school settings. The effect was not confirmed for abdominal muscle endurance. Future studies should use randomized or cluster-randomized designs, longer follow up periods, and objective posture assessment methods.

Trial registration

Not applicable. This study was conducted as a schoolbased posture awareness intervention and did not involve clinical treatment.

Introduction

Posture training has become increasingly important due to the widespread prevalence of sedentary lifestyles and physical inactivity [1]. Musculoskeletal conditions are among the leading causes of disability worldwide [2]. Low back pain, in particular, remains the most prevalent musculoskeletal condition and continues to be the leading cause of disability globally [3]. These findings highlight the importance of early preventive approaches, especially in school-aged populations.

As students' postural status can be influenced by several factors, including rapid growth, poor nutrition, and lack of physical activity, strengthening weaker abdominal and back muscles may be important in school-based prevention programs [4].

In Hungary, daily physical education was mandated in primary and secondary schools in 2012 as a preventive measure against cardiovascular, metabolic, and locomotor disorders. The importance of posture training is also emphasized in the National Curriculum, 2020 [5]. In school settings, primary prevention may include posture training, appropriate ergonomic conditions, such as adequate chair and desk height, and learning correct sitting posture. The weight of school bags is also relevant, as it should not exceed 10% of body weight. In addition, the early and frequent use of digital devices may contribute to the development of "text neck" and other posture-related problems among younger generations [6].

From Strengthening and Stretching Exercises to Muscle Control

Several approaches have been developed to address muscle imbalance and posture-related problems. Earlier therapeutic approaches focused mainly on strengthening and stretching exercises to restore damaged or weakened muscles [7, 8]. Later developments in posture training emphasized functional exercises, which support the integration of muscle function into habitual movements and everyday actions [9]. Isolated muscle exercises alone do not necessarily teach integration into habitual movement patterns. Rather, they mainly serve as physical corrections for unsafe habits [10].

Experts in posture development have also emphasized the role of body awareness and muscle consciousness. This can be seen in approaches such as Body Mind Centering [11], the Feldenkrais Method® [12], and the Schroth method [13]. Modern approaches increasingly focus on teaching habitual actions through muscle control [14]. Recent research has also examined posture assessment, including studies focusing on head posture assessment [15] and technology-supported posture assessment systems, such as the use of Microsoft Kinect for the Ovako Working Posture Assessment System [16].

Posture training exercises for different age groups, from kindergarten to adulthood, were developed by the Hungarian Spine Society. In addition to strengthening and stretching exercises, this program emphasizes body awareness in everyday actions, such as standing and sitting [17]. Although several of the previously mentioned methods are difficult to apply systematically in secondary school settings, the Hungarian Spine Society's program is appropriate for this age group because it emphasizes not only strengthening and stretching, but also the teaching of habitual actions through muscle awareness.

Correct posture of the spine, thorax, and shoulder girdle depends partly on the position of the pelvis and the lower extremity joints. Therefore, posture training aims to correct inappropriate habitual posture and restore muscle function [8]. Strength development is not only the result of changes within the muscles themselves, but also involves adaptations in the central nervous system [19]. However, Clark et al. (2023) emphasize that further refinement of current approaches is needed to better support peripheral joint health in the long-term [20].

A key challenge is how posture control can be practiced and maintained in everyday settings. Partido et al. (2021) demonstrated that self-assessment and photography may help reduce the risk of musculoskeletal disorders among dentists and dental hygienists [21]. However, school-based posture training often focuses mainly on exercises, while the repeated recall and application of correct posture throughout the day remain more difficult to achieve. Moreover, existing approaches provide limited practical guidance on how students can be supported in remembering and applying posture control during their daily school routines.

Therefore, the present study focuses on the development of habitual posture control and self-assessment among high school students. More specifically, it examines whether a relatively short posture awareness intervention conducted in a school setting, combining functional posture exercises with regular posture-control reminders, can support body awareness and posture-related muscle endurance under everyday school conditions.

Materials and methods

Participants

The study involved 182 high school students, including 73 boys and 109 girls, from three secondary schools in Budapest, Hungary. The mean age of the participants was 16.08 ± 0.60 years.

Purposeful sampling was used to select the participating schools. Several criteria were considered during school selection. First, schools had to be ranked within the top 25% of the public education system. Second, the inclusion of both state-funded and non-state-funded schools was required. Accordingly, one state-funded and two church-funded secondary schools were included in the study. Each school contributed two classes. The selected classes were assigned to either the Posture Group or the Control Group. As a result, both groups included students from more than one school, which was intended to increase sample heterogeneity and reduce the potential influence of school-specific factors.

Of the total sample, 3.4% of students reported participating in obligatory posture training prescribed by an orthopedic doctor on a daily basis or two to three times per week, while 5.7% reported participating in such training once per week. Regarding extracurricular physical activity, 36.2% of students reported being physically active three or more times per week, 45.6% once or twice per week, and 18.2% rarely or never.

The Posture Group included 77 students, 30 boys and 47 girls, with a mean age of 16.61 ± 0.49 years. The Control Group included 105 students, 45 boys and 60 girls, with a mean age of 15.92 ± 0.70 years (Table 1).

Table 1
Baseline Characteristics of the Study Sample

Variable	**Posture Group (n = 77)**	**Control Group (n = 105)**
Boys, n (%)	30 (39.0)	45 (42.9)
Girls, n (%)	47 (61.0)	60 (57.1)
Age, M ± SD	16.61 ± 0.49	15.92 ± 0.70
Extracurricular physical activity > 3 times/week, n (%)	32 (41.6)	40 (38.1)
Extracurricular physical activity 1 to 2 times/week, n (%)	35 (45.5)	45 (42.9)
Extracurricular physical activity rarely or never, n (%)	10 (13.0)	20 (19.0)
Prescribed posture training daily or 2 to 3 times/week, n (%)	4 (5.2)	1 (1.0)
Prescribed posture training once/week, n (%)	2 (2.6)	5 (4.8)
No prescribed posture training, n (%)	71 (92.2)	99 (94.3)
Note. M = mean, SD = standard deviation. Percentages are calculated within each group.		

Study design

This study used a quasi-experimental pretest and posttest control group design to examine the effects of a 7-week school-based posture awareness intervention on posture-related muscle endurance and body awareness among high school students. The groups were formed at class level rather than through individual randomization. Therefore, the study should be interpreted as a school-based quasi-experimental intervention.

Both groups received general information about correct posture. This included a classroom-based presentation, individual explanations, and visual demonstrations of correct and incorrect postures. Possible corrections were presented through strengthening and stretching exercises, as well as through correct functional and habitual actions. Demonstrations used pictures, photographs, and everyday movements to help students identify and feel the role of their muscles during posture control. The main focus was placed on pelvic position, as correct pelvic alignment is considered central to proper posture and movement execution [17, 18].

In addition to the standard physical education curriculum and the introductory posture-related information, the Posture Group received weekly functional posture training and daily posture-control reminders. The holding strengthening exercises were based on Steady Motion Fitness and were selected according to their posture-related function [22, 23]. The intervention focused on the conscious control of posture during static positions, dynamic movements, and everyday habitual actions.

Nikšić et al. (2020) suggest that the mutual action and engagement of professionals working with young people can have a positive influence on their postural status [4]. In line with this perspective, the intervention included regular teacher reinforcement and reminder signals approximately every two-hours to support the repeated recall of correct posture during the day. The purpose of the reminder was not to measure posture objectively, but to help students interrupt prolonged habitual sitting or standing positions and consciously check their pelvic, spinal, and shoulder girdle alignment. The two-hour interval was selected as a practical school-based compromise, considering that sustained attention is limited and that posture control needs to be recalled repeatedly in everyday contexts [17]. During school hours, the school-bell served as the reminder signal. After school, students were encouraged to use their own mobile phones as reminders.

This reminder-based method was conceptually related to health applications that use prompts to support self-monitoring and health-related behavior change. Previous studies have emphasized that such tools may support users' active participation in treatment or prevention, particularly when they are informative and easy to integrate into daily routines [24, 25]. In the present study, however, mobile phones were used only as reminder tools, not as measurement devices. This distinction is important because smartphone-based posture assessment applications have mostly been evaluated for specific biomechanical indicators, such as the craniovertebral angle, whereas the present intervention focused on posture awareness and self-monitoring rather than digital posture assessment [26].

At the beginning of the intervention, students in the Posture Group were also asked to keep daily records of posture awareness. However, only a small number of students were willing to complete these records consistently. Therefore, this component was not retained as a formal measurement tool. Instead, physical education teachers regularly reminded students to observe and correct their posture during the intervention period. The purpose was to develop a feasible posture awareness method that could be applied in everyday school settings with limited resources.

The Control Group received the standard physical education curriculum and the same introductory posture-related information as the Posture Group, but did not receive the additional weekly functional posture training or the regular posture-control reminders.

The program components and the detailed intervention protocol for the Posture Group are presented in Tables 2 and 3.

Table 2
Components of the Seven Week School-Based Posture Awareness Program

Program Component	Posture Group	Control Group
Standard physical education curriculum	Yes	Yes
Introductory posture education	Yes	Yes
Explanation of correct and incorrect posture	Yes	Yes
Visual demonstration using pictures and photographs	Yes	Yes
Demonstration of correct sitting, standing, and habitual movements	Yes	Yes
Basic strengthening and stretching instructions	Yes	Yes
Weekly functional posture training	Yes	No
Strengthening and stretching exercises three times per week	Yes	No
Daily posture-control reminders approximately every two-hours	Yes	No
Teacher reinforcement related to posture awareness	Yes	No

Note. Both groups received the standard physical education curriculum and introductory posture education. The additional intervention components were provided only to the Posture Group.

Table 3
Intervention Protocol for the Posture Group

Time	Target	Habitual Posture Training
Week 1	Static positions with correct posture	Standing positions, including closed stance, normal stance, straddle stance, half squat, and kneeling
Week 2	Static positions with correct posture	Sitting at different heights, including chair, desk, and floor positions, and in different sitting positions, such as cross-legged and sitting on the heels
Week 3	Dynamic movements with correct posture	Walking at different speeds, jogging, and running
Week 4	Dynamic movements with correct posture	Arm lifting to different heights, trunk bending forward at 45° and 90° angles, lateral trunk bending, and trunk rotation
Week 5	Combination of movement elements	Sitting down and standing up from different heights
Week 6	Combination of movement elements	Lifting and lowering objects
Week 7	Individual habitual actions	Practice of individual everyday posture-related actions

Note. The intervention emphasized posture control with tilted pelvis, closed scapulae, and shoulders lowered during habitual movements.

Measures

Measurements were taken before and after the 7-week intervention period. Data were collected using posture-related muscle endurance tests, the Body Awareness Questionnaire, and a short questionnaire developed for this study. This instrument was used to assess self-reported daily posture monitoring after the intervention, and the variable was treated as nominal data.

A short study-specific survey was used to collect demographic and background information, including gender, age, school or class code, extracurricular physical activity, participation in prescribed posture training, and self-reported daily posture monitoring during the intervention period. The English version of the study-specific survey items used in the present analysis is provided as Supplementary File 1.

Posture-related muscle endurance was assessed using two holding-position exercises from the Hungarian Spine Society's posture training program. These exercises measured the endurance of the back and abdominal muscles in seconds [17]. The back muscle endurance test and the abdominal muscle endurance test were treated as continuous variables.

Body awareness was assessed using the Hungarian version of the Body Awareness Questionnaire. The Hungarian version was validated by Köteles (2014), who examined body awareness among yoga practitioners and young adult controls [27]. Due to its interpretability, the questionnaire was considered suitable for use among secondary school students.

The primary outcome of the study was change in body awareness, assessed by the Body Awareness Questionnaire. Secondary outcomes were back muscle endurance, abdominal muscle endurance, and self-reported daily posture monitoring.

Data analysis

Descriptive statistics were used to summarize the main characteristics of the sample. Continuous variables are presented as means and standard deviations, while categorical variables are presented as frequencies and percentages. Baseline differences between the Posture Group and the Control Group were examined using independent-samples t tests for continuous variables and chi-square tests for categorical variables.

Before the main analyses, the distribution of continuous variables was examined using visual inspection of histograms and Q-Q plots. Homogeneity of variances was assessed using Levene's test. For the ANCOVA models, the assumption of homogeneity of regression slopes was tested by examining the interaction between group and the corresponding baseline value. If this interaction was not statistically significant, the final ANCOVA model was interpreted without the interaction term.

Intervention effects on body awareness and posture-related muscle endurance were examined using analyses of covariance. Separate ANCOVA models were fitted for Body Awareness Questionnaire score, back muscle endurance, and abdominal muscle endurance. In each model, the postintervention value was entered as the dependent variable, group allocation was entered as the fixed factor, and the corresponding baseline value was entered as a covariate. Thus, baseline Body Awareness Questionnaire score, baseline back muscle endurance, and baseline abdominal muscle endurance were controlled in their respective models.

Self-reported daily posture monitoring was compared between groups using a chi-square test. Effect sizes were reported where appropriate. For ANCOVA models, adjusted group effects, F values, p values, and omega squared values were reported. Statistical significance was set at $p < .05$. Analyses were conducted using SPSS 25.0 for Windows and JASP.

Results

Self-Reported Posture Monitoring

A significantly higher proportion of students in the Posture Group reported monitoring their posture during the day compared with students in the Control Group. In the Posture Group, 53.2% of students reported daily posture monitoring, whereas this proportion was 13.3% in the Control Group (Table 4). The difference between the groups was statistically significant, $\chi^2(1) = 43.718$, $p < .001$.

Table 4
Daily Posture Monitoring During the Program

Group	Yes	No
Posture Group	53.2%	46.8%
Control Group	13.3%	86.7%

Changes in Posture-Related Muscle Endurance

Descriptive results showed that the Posture Group had higher baseline values than the Control Group in both back muscle endurance and abdominal muscle endurance. In the Posture Group, mean back muscle endurance increased from 117.31 ± 46.71 s at baseline to 140.59 ± 66.25 s after the intervention. In the Control Group, mean back muscle endurance increased from 94.01 ± 57.26 s to 102.53 ± 51.32 s (t=-3,294; df = 76; p = 0,002).

For abdominal muscle endurance, both groups showed descriptive increases from baseline to postintervention, with no clear descriptive advantage for the Posture Group. The Posture Group increased from 389.30 ± 157.42 s to 400.00 ± 162.96 s, while the Control Group increased from 347.93 ± 198.14 s to 374.72 ± 186.50 s (Table 5).

Table 5
Pretest and Posttest Values for Posture-Related Muscle Endurance

Outcome	Group	Pretest, M ± SD	Posttest, M ± SD	t	Sig. (2-tailed)
Back muscle endurance, s	Posture Group	117.31 ± 46.71	140.59 ± 66.25	-3,294	0.002
	Control Group	94.01 ± 57.26	102.53 ± 51.32	-1,847	0.91
Abdominal muscle endurance, s	Posture Group	389.30 ± 157.42	400.00 ± 162.96	-,807	0.422
	Control Group	347.93 ± 198.14	374.72 ± 186.50	-1,347	0.181
Note. M = mean, SD = standard deviation, s = seconds.					

Changes in Body Awareness

At baseline, the Control Group had a slightly higher mean Body Awareness Questionnaire score than the Posture Group. The Posture Group increased from 70.77 ± 11.00 at baseline to 73.97 ± 11.70 after the intervention. In contrast, the Control Group showed a small decrease from 71.72 ± 15.15 to 71.50 ± 13.98 (p = 0.003) (Table 6).

Table 6
Pretest and Posttest Values for Body Awareness Questionnaire Scores

Group	Pretest M ± SD	Posttest M ± SD	t	Sig.
Posture Group	70.77 ± 11.00	73.97 ± 11.70	-3.458	0.003
Control Group	71.72 ± 15.15	71.50 ± 13.98	1.102	0.273
Note. M = mean, SD = standard deviation.				

Baseline Adjusted Intervention Effects

After adjustment for baseline values, ANCOVA showed significant group effects for back muscle endurance and body awareness, but not for abdominal muscle endurance. The assumption of homogeneity of variance was met for back

muscle endurance and body awareness, while it was not met for abdominal muscle endurance. Therefore, the abdominal muscle endurance result should be interpreted with caution. The ANCOVA results are summarized in Table 7.

Table 7
Summary of ANCOVA Group Effects for Posture-Related Muscle Endurance and Body Awareness

Outcome	Baseline Covariate	F	df	p	ω²	Interpretation
Back muscle endurance	Baseline back muscle endurance	9.633	1, 177	.002	.033	Significant group effect
Abdominal muscle endurance	Baseline abdominal muscle endurance	0.025	1, 179	.874	.000	No significant group effect
Body awareness	Baseline Body Awareness Questionnaire score	8.804	1, 179	.003	.019	Significant group effect

Note. ANCOVA = analysis of covariance, ω² = omega squared. Each model included group as the fixed factor and the corresponding baseline value as the covariate. Levene's test was not significant for back muscle endurance, F(1, 178) = 1.640, p = .202, or body awareness, F(1, 180) = 0.885, p = .348. Levene's test was significant for abdominal muscle endurance, F(1, 180) = 9.979, p = .002. Therefore, the abdominal muscle endurance result should be interpreted with caution.

Discussion

The present study examined the effects of a 7-week school-based posture awareness intervention on body awareness, posture-related muscle endurance, and self-reported posture monitoring among high school students. The main findings suggest that the intervention had a favorable effect on body awareness and back muscle endurance after controlling for baseline values. In addition, students in the Posture Group reported daily posture monitoring more frequently than students in the Control Group. However, the intervention effect was not confirmed for abdominal muscle endurance.

The results support the assumption that posture training should not be limited to strengthening and stretching exercises alone. Effective posture correction also requires the conscious integration of correct posture into habitual actions, such as sitting, standing, walking, and lifting. This is consistent with the view that posture training should include both physical conditioning and the development of body awareness in everyday movement contexts [8, 17]. In the present study, the Posture Group received not only functional posture exercises, but also regular posture-control reminders and teacher reinforcement. These elements may have helped students recall and apply correct posture more frequently during the day.

A significantly higher proportion of students in the Posture Group reported monitoring their posture during the day compared with students in the Control Group. This finding indicates that the reminder-based component of the intervention may have supported the transfer of posture-related knowledge into daily school routines. The Control Group received introductory posture information but did not receive regular reminders or additional functional posture training. Therefore, the difference between the groups suggests that repeated recall and reinforcement may be important for developing posture awareness in adolescents.

The ANCOVA results showed a significant group effect for back muscle endurance after adjustment for baseline values. This suggests that the intervention may have contributed to improved endurance of posture-related back muscles. One possible explanation is that the functional exercises and repeated posture-control reminders increased the students' awareness and activation of muscles involved in maintaining correct posture. Strength development is not only related to muscular adaptation, but also to central nervous system processes involved in motor control and coordination [19]. Therefore, the combination of functional practice and conscious posture monitoring may have supported neuromuscular adaptation in the Posture Group.

In contrast, no significant group effect was found for abdominal muscle endurance after controlling for baseline values. Although both groups showed some descriptive improvement, the adjusted analysis did not support a clear intervention

effect. This result should be interpreted cautiously because the assumption of homogeneity of variance was not met for this outcome. Nevertheless, the finding suggests that the intervention was more effective for back muscle endurance than for abdominal muscle endurance. One possible explanation is that the intervention content may have been more directly related to upright posture control and back muscle activation than to isolated abdominal endurance development.

Body awareness also improved more favorably in the Posture Group than in the Control Group. After adjusting for baseline Body Awareness Questionnaire scores, the group effect remained significant. This supports the relevance of including self-monitoring and conscious body control in school-based posture training. The Body Awareness Questionnaire has previously been used to assess body awareness, including comparisons between yoga practitioners and young adult controls [27]. In the present study, the increase in body awareness among high school students suggests that posture awareness can also be developed in a school-based setting when exercises are combined with repeated reminders and teacher support.

The findings may be relevant for musculoskeletal prevention programs implemented in school settings. Posture training may be more effective when students are not only instructed how to perform correct posture but are also supported in recalling and applying it repeatedly during the day. Regular reminders, school-bell cues, mobile phone prompts, and teacher reinforcement may be feasible tools for integrating posture awareness into everyday school routines. These methods require limited resources and may therefore be applicable in secondary school contexts.

Several limitations should be considered. First, the study used a quasi-experimental design, and the groups were formed at class level rather than through individual randomization. Second, the Posture Group and the Control Group differed in some baseline characteristics, including age and initial muscle endurance values. Although ANCOVA was used to control for baseline differences, residual confounding cannot be excluded. Third, daily posture monitoring was assessed by self report, which may be influenced by recall bias or social desirability. Fourth, the intervention lasted only 7-weeks, so the long-term maintenance of posture awareness and muscle endurance improvements remains unknown. Finally, objective biomechanical posture assessment was not included. Therefore, the study focused on body awareness and muscle endurance rather than direct measurement of postural alignment.

In conclusion, the findings suggest that a short school-based posture awareness intervention combining functional posture exercises, regular posture-control reminders, and teacher reinforcement may support body awareness and back muscle endurance among high school students. These results indicate that posture awareness and repeated self-monitoring may be feasible elements of adolescent musculoskeletal prevention in school settings. However, the effect was not confirmed for abdominal muscle endurance. Future studies should use randomized or cluster-randomized designs, longer follow up periods, and objective posture assessment methods to examine the long-term effectiveness of school-based posture awareness programs.

Declarations

Ethics approval and consent to participate:

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study received approval from the Institutional Review Board of Eszterházy Károly Catholic University (Approval ID: RK/1243/2021). Prior to the intervention, written informed consent was obtained from all participants and from their parents or legal guardians during a teacher-parent conference held at the respective schools. The consent process included detailed information about the nature and scope of the intervention. Participants and their parents or guardians were fully informed about the purpose of the study, the voluntary nature of participation, the intended use of the data, and the measures taken to ensure anonymity and confidentiality. They were also informed about any potential risks associated with participation.

Competing interests:

The authors declare that they have no competing interests.

Consent for publication:

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Author Contribution

Abonyi, Barbara: research concept, design of the work, literature review, data collection, interpretation of data, drafting the work, final approval of the version to be published.Simon, István Ágoston: literature review, interpretation of data, drafting the work, final approval of the version to be published.Bognár, József: research concept, interpretation of data, reviewing the draft, final approval of the version to be published.Acknowledgements: the authors thank for all the participants for being part in the study.

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Data Availability

Data supporting this study are available from Barbara Abonyi (Eszterhazy Karoly Catholic University) upon reasonable request and subject to a data sharing agreement due to ethical restrictions.

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