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Effect of digital health corrective posture exercise program on head and shoulder posture in adolescents

A cluster randomized controlled trial

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Abstract

Background: Poor posture, particularly forward head posture and rounded shoulders, has become increasingly prevalent among adolescents due to prolonged screen use and sedentary behaviors. This study aimed to investigate the effects of a 6-week digital health corrective posture exercise (DHCPE) program on head and shoulder posture in adolescents.

Methods: A total of 36 subjects were recruited and randomly allocated to 3 groups: the DHCPE group, the face-to-face exercise (FTFE) group, and a control group. The DHCPE and FTFE groups participated in the same corrective posture exercise programs. The DHCPE group conducted the digital health intervention remotely through a monitored screen, while the FTFE group engaged in corrective posture exercises on-site with therapists. Each intervention lasted 50 minutes and was conducted 3 times a week over a period of 6 weeks for both groups. The outcome measurements included protracted head and shoulder distances, trunk lean (the angle of shoulder inclination relative to the pelvis), trunk deviation, shoulder and pelvic height levels, and the absolute differences and inequality ratios between both sides. All assessments were conducted both preintervention and postintervention.

Results: Both the DHCPE and FTFE groups demonstrated significant improvements in protracted head, left protracted shoulder, and trunk lean following the intervention. The interaction effect revealed that both the DHCPE and FTFE groups exhibited significant improvements in these measurements compared with the control group. Furthermore, no significant differences were found between the improvements observed in the DHCPE group and those in the FTFE group.

Conclusion: DHCPE and FTFE were effective in improving head and shoulder posture in adolescents. The improvements in the DHCPE group were comparable to those achieved in the FTFE group. DHCPE has the potential to serve as a viable alternative to FTFE for enhancing head and shoulder posture in this population.

Abbreviations: DHCPE = digital health corrective posture exercise, DHI = digital health intervention, FH = forward head, FTFE = face-to-face exercise, PL = pelvic level, RS = rounded shoulder, SL = shoulder level.

Keywords: adolescents, corrective posture exercise, digital health intervention, posture

1. Introduction

During adolescence, extended use of smartphones, computers, and other electronic devices, along with excessive sedentary behavior, frequently contributes to poor position and common postural misalignments.[1,2] These typically present as specific clinical issues, such as forward head (FH) and rounded shoulders (RS). FH is defined by the head's protrusion in front of the trunk. In FH posture, the head's excessive anterior displacement is measured relative to a vertical reference line. RS is characterized by protracted and forward-leaning shoulders, which may suggest discomfort or strain in the cervical spine due to misalignment.[3,4] Both FH and RS negatively affect scapular positioning, kinematics, and muscle balance. This can lead to increased muscle tension,

C-YB and J-HA contributed equally to this work.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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muscle shortening, and additional stress on the cervical spine and shoulders.[4] Early and prolonged postural habits from everyday life can lead to ongoing musculoskeletal problems and increase the risk of neck and shoulder pain in early adulthood,[5] potentially speeding up degenerative changes that may occur later in life.[6] Moreover, these postural misalignments are linked with headaches and myofascial pain syndrome.[7]

Digital health intervention (DHI) approach involves the use of information and communications technologies, such as smartphone apps, sensors, videos, social media platforms, and wearable technologies, to achieve health-related objectives.[8] In particular, various exercise programs integrated with DHI have been applied not only to older adults but also to patients with musculoskeletal, neurological, and cardiopulmonary conditions.[9–11] This approach serves as a significant factor in enhancing rehabilitation services by improving accessibility, affordability, and scalability.[12] That is, it could offer the advantage of providing low-cost, highly effective, and tailored rehabilitation remotely. A previous study has shown that DHIs have improved pain and disability in patients with nonspecific neck pain.[13] Another study demonstrated that a DHI based on telerehabilitation effectively reduced pain levels in patients with nonspecific neck and shoulder pain.[14] However, most studies on digital exercise prescriptions have been limited to areas such as elderly health, fall prevention, chronic obstructive pulmonary disease, and cardiovascular disease.[8,9,11,13]

There is a notable lack of studies addressing various quantitative postural parameters in adolescents, a population particularly sensitive to postural misalignments such as FH and RS. Furthermore, there is insufficient research on the impact of digital health corrective posture exercise (DHCPE) programs on these postural alignment issues in such adolescents.[15,16] Therefore, this study aims to investigate the effects of a 6-week DHCPE on the head and shoulder posture of adolescents. The findings could contribute to the development of effective digital health intervention (DHI) programs for adolescents frequently exposed to postural misalignments and may also have potential applications for adults experiencing FH and RS posture accompanied by pain. Furthermore, this research could provide guidance on various approaches for applying DHI to rehabilitation services. The study hypothesizes the following:

(1) DHCPE would result in improvements in head and shoulder posture among adolescents following the intervention. (2) The DHCPE group would demonstrate significant enhancements in head and shoulder posture compared to the control group, which does not participate in any intervention. (3) DHCPE would produce similar improvements in head and shoulder posture as those achieved through a face-to-face exercise (FTFE) program among adolescents.

2. Methods

2.1. Participants

This study received approval from the Institutional Review Board (IRB) at Korea University (IRB-2023-0448) and was conducted from February 13 to March 29, 2024. All procedures adhered to the principles outlined in the Declaration of Helsinki. Participants were recruited from middle and high schools through informational materials that outlined the research topic, inclusion criteria, procedures, and study locations. The inclusion criteria were adolescents aged 14 to 17 who were capable of following the exercise instructions provided by the researcher and had not been diagnosed with orthopedic conditions such as fractures or sprains within the past 6 months. Exclusion criteria included individuals experiencing pain in the neck, back, or shoulders, as well as those involved in other intervention studies, or participants with regular physical activities that could influence the results of the study. All participants provided written informed consent before participating in the study.

2.2. Study design

The study design was a cluster randomized controlled trial with 3 parallel groups (Fig. 1). A total of 36 participants were categorized by school and class level, and then randomly assigned at the cluster level, specifically using the class level, through a random number table generated in Microsoft Excel. Specifically, 12 participants were allocated to Experimental Group I (DHCPE), 12 to Experimental Group II (FTFE), and 12 to the control group. Postural assessments were conducted both before the intervention and after 6 weeks of intervention. Participants in each group were not permitted to share information about their interventions. All assessments were carried out by the same evaluator using the same evaluation guide, both before and after the intervention, at the same evaluation room.

2.3. Assessment device and data processing

In this study, static postures of participants were measured using the 4DEYE® posture capture device (SYM Healthcare Inc., Seoul, Korea), which utilizes multi-view red, green, and blue (RGB) imaging[17,18] and was preinstalled in the evaluation room. The 4D EYE® consists of 5 cameras and estimates three-dimensional postures without the need for special markers. It automatically recognizes and outputs a total of 27 landmarks using a markerless multi-view imaging sensor, thereby analyzing the subject's motion and posture (Fig. 2). The equipment demonstrated high intra-reliability ($ICC_{3,1}$ = 0.773–0.974) and exhibited high concurrent validity ($ICC_{3,k}$ = 0.747–0.936) when compared with the Vicon motion capture system.[19] In the present study, this capability allows for real-time or offline observation of head and shoulder postures through a skeletal model (Fig. 2). In the evaluation procedure, only 2 researchers and 1 participant are allowed in the measurement room. The roles are divided between a researcher who provides measurement instructions and another researcher who performs the posture assessment, with both researchers involved before and after the intervention. Each participant undergoes the evaluation individually in the measurement room. During the assessment, participants position themselves on a measurement platform (60 cm × 60 cm) maintaining a 2-meter distance from the front camera of the 4D EYE®. Following the researcher's command to "start," participants hold a natural standing posture for 2 to 3 seconds. The evaluation is conducted twice, and the values are averaged. A 30-second rest period is provided between assessments. To ensure consistent landmark detection during the evaluation, participants wore clothing that fit their body size, excluding outerwear, and wore the same clothing before and after the assessment. The measuring researcher ensures that participants adopt a relaxed posture rather than intentionally straightening up. Additionally, white plastic partitions (each 2 meters high and 4 meters wide) are installed around the measurement area to minimize device identification errors, and external light sources are blocked to reduce measurement errors of the RGB markerless multi-view imaging sensor.

Participants' static postures are photographed at 12 Hz from 5 different directions using a custom analysis program based on OpenCV and Google's open-source self-estimation software, Mediapipe Blazepose. The software captures 5 images simultaneously from 5 cameras, identifying the 2D positions of key points, including the eyes, nose, ears, shoulders, elbows, wrists, and ankles (Fig. 2). Using the relative positions and orientations of the cameras, the 3D positions of these key points are reimplemented from 5 2D images corresponding to each key point using OpenCV software. The collected data are then saved in a excel file for the analysis of the 3D static posture of the head and shoulders.

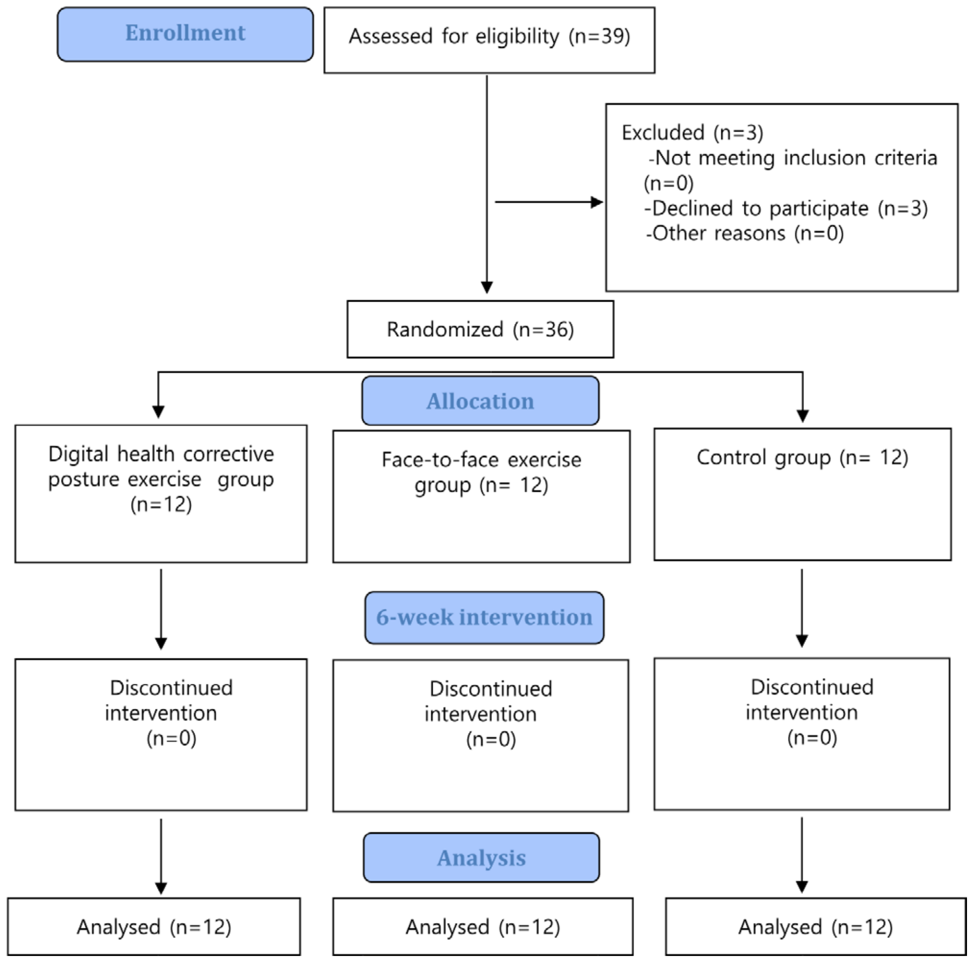

Figure 1. Flow diagram of the study.

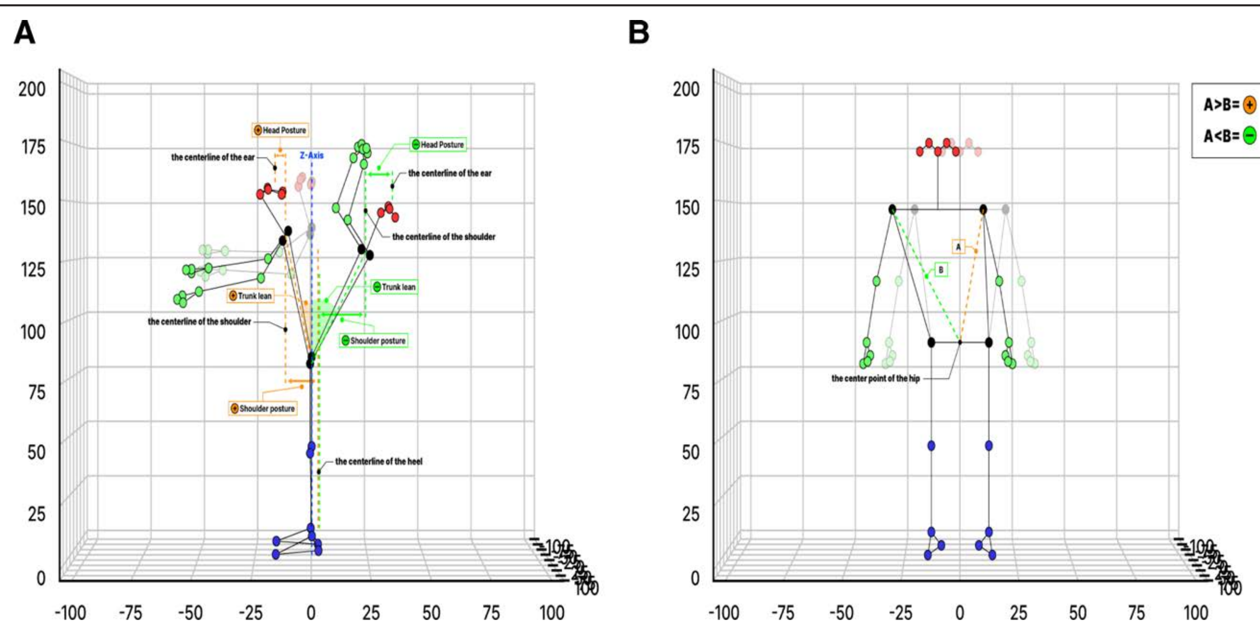

Figure 2. Skeleton model in 4DEYE during natural standing position. (A) Posture evaluation in the sagittal plane. (B) Posture evaluation in the frontal plane. The key anatomical points include the nose, eye, ear, shoulder joint (center), elbow joint (center), wrist joint (center), thumb, index finger, little finger, hip joint (center), knee joint (center), ankle joint (center), heel, and toe.

2.4. Outcome measurements

The outcome measurements included protracted head and shoulder distances, trunk lean, trunk deviation, shoulder and pelvic height levels, and the absolute differences and inequality ratios between both sides. All assessments were conducted both pre- and post-intervention. Head posture is defined as the distance (in centimeters) between the center of the ear and the center of the shoulder in the sagittal plane while standing in a neutral posture. Protracted shoulder is defined as the distance (in centimeters) between the shoulder center and the heel center in the same neutral stance.[15,20] Positive values (+) indicate protracted positions of the head and shoulders, while negative values (−) indicate retracted positions in the sagittal plane. In head and shoulder posture measurements, a value closer to 0 cm reflects a more correct posture. Furthermore, in the measurement of shoulder posture, the position of the shoulders relative to the trunk (i.e., trunk lean) is specifically assessed. This is measured by the angle between a vertical line and the line connecting the centers of the shoulders and hips (Fig. 2a). A positive value (+) indicates that the shoulders are positioned anteriorly relative to the hips, while a negative value (−) indicates that the shoulders are positioned posteriorly. A negative value suggests alignment consistent with an upright posture, characterized by a straight spine and retracted shoulders.[15,20] Additionally, to assess postural asymmetry, we examined trunk deviation as well as the positions of the shoulders and pelvis in the frontal plane. This approach enables a quantitative analysis of asymmetry and enhances our understanding of trunk alignment. In the assessment of trunk deviation, we calculated the absolute value of the difference in distance between the center point of both hip joints and the center of the right shoulder, compared to the center of the left shoulder (Fig. 2b). Both shoulder (SL) and pelvic levels (PL) were measured, and the absolute value of the difference between the 2 sides was computed. Furthermore, asymmetry between the shoulders and pelvis was quantified to inequality using the formula (absolute difference/longer side) × 100%. To minimize compensatory postures, we conducted a multidimensional evaluation that encompassed both sagittal and frontal planes, as well as various parameters related to the pelvis and shoulders that could influence trunk alignment, in addition to head and shoulder posture parameters.[21–23]

2.5. Intervention

The exercise programs included a 10-minute warm-up consisting of light upper and lower joint exercises and stretching, followed by 30 minutes of main exercises, and concluded with a 10-minute cool-down involving deep breathing and stretching, all conducted as group exercises. The total duration was 50 minutes, and the exercise program took place in the school auditorium with only each participant present and the environment kept quiet to minimize potential factors interfering with the program. Both the DHCPE and FTFE groups participated in a restructured postural correction exercise program consisting of 12 exercises targeting muscles associated with upper cross syndrome.[3,20,24,25] The program focused on stretching, strengthening, and spine mobility exercises, conducted for 30 minutes with consistent timing and structure for both groups (Table 1). The DHCPE group received the exercise program via a large monitor, with guidance and supervision to prevent errors and ensure proper execution. The FTFE group performed the program under the direct supervision of a physical therapist and a health exercise specialist (Fig. 3). The control group did not receive any exercise program. Detailed exercise methods are described in the Appendix S1, Supplemental Digital Content, http://links.lww.com/MD/O550.

2.6. Statistical analysis

All statistical analyses were done with SPSS 18.0 (IBM SPSS, Chicago, IL).

Data were presented as means with standard deviations. Differences in participant characteristics between groups were checked using one-way ANOVA for continuous variables and chi-square tests for categorical variables. Comparisons between groups and within groups were conducted using a 3 × 2 repeated measures ANOVA, with group as a between-subjects factor and pre- and post-intervention as within-subjects factors, along with paired *t* tests, based on the normality of the distribution of the variables. Additionally, for the outcome variables where interactions were identified, age was included as a covariate to confirm that there were no interactions influenced by age. The significance level for all statistical tests was set at $\alpha = 0.05$. This study conducted Tukey HSD test for post hoc analysis, as the sample size was the same across all groups. Sample size calculations were performed using G*Power 3.1. With a medium effect size $F = 0.25$, an alpha level of 0.05, and a power of 0.95, the calculated sample size was 36 participants. To account for a 10% dropout rate, as recommended for clinical research, the final sample size was adjusted to 39 participants.

3. Result

For this study, 39 participants were initially recruited; however, 3 individuals withdrew prior to the start of the intervention due to personal reasons, resulting in a total of 36 participants. All 36 completed the 6-week intervention period without any dropouts. The effectiveness of the intervention can depend on participation and program adherence. Therefore, we monitored these factors weekly across all groups, and all participants attended without any absences. No adverse events

Table 1

Corrective posture exercise programs.

Order	Exercise	Purpose	Repetitions	Duration
1	Self-neck stretch	Stretching for splenius capitis	30 seconds × 3 sets	10 minutes
2	Upper trapezius stretch	Stretching for upper trapezius	30 seconds × 3 sets	
3	Scalene stretch	Stretching for scalene	30 seconds × 3 sets	
4	Pectoralis major stretch—head turn	Stretching for pectoralis major	30 seconds × 3 sets	
5	Seated chin tuck—over pressure	Strengthening for deep neck flexors	8 reps × 2 sets	10 minutes
6	Deep neck flexion		8 reps × 2 sets	
7	Supine chin tuck—lift, isometric		30 seconds × 2 sets	
8	Chin tuck to neck extension		8 reps × 2 sets	
9	Quadruped neck segmental flexion & extension	Active range of motion exercises for the cervical spine	8 reps × 2 sets	10 minutes
10	Quadruped open book—arms behind head	Active range of motion exercises for the thoracic spine	8 reps × 2 sets	
11	Prone Ys	Strengthening for lower trapezius	8 reps × 2 sets	
12	Prone Ws—head lift	Strengthening for rhomboid	8 reps × 2 sets	

Figure 3. Corrective posture exercise among groups. (A) Digital health corrective posture exercise group with a monitored screen. (B) Face-to-face exercise group with therapists.

occurred during the study. There were no significant differences in any of the characteristics among the groups, excluding age (Table 2).

In terms of head posture, significant differences were observed between pre-intervention and post-intervention measurements in both the DHCPE and FTFE groups ($P < .001$) (Table 3). Between-group comparisons revealed that both the DHCPE and FTFE groups exhibited significant improvements compared to the control group ($P < .001$), along with a significant interaction effect. In terms of shoulder posture, significant differences in left protracted shoulder were observed between pre-intervention and post-intervention in both the DHCPE ($P < .01$) and FTFE ($P < .05$) groups. Between-group comparisons indicated a significant interaction (Table 3), with both intervention groups demonstrating significant improvements over the control group ($P < .05$). Furthermore, all groups exhibited significant differences in trunk lean between pre- and post-intervention. Both the DHCPE and FTFE groups showed improvements ($P < .05$), while the control group displayed a decline ($P < .05$). In the comparison between groups, both intervention groups demonstrated significant improvements relative to the control group ($P < .05$) with interaction effect presented. The values for left and right trunk lean showed the same results (Table 3).

In terms of upper body postural asymmetry, the DHCPE group demonstrated significant changes in shoulder level on both sides ($P < .05$). The FTFE group exhibited significant differences in SL absolute difference and SL inequality compared to the control group ($P < .05$). However, no significant interactions were found that could explain the differences between the groups. Regarding lower body postural asymmetry on PL, no significant differences were observed either within or between the groups (Table 4).

Furthermore, the results of the analysis, with age included as a covariate, indicated that the significant interactions for group comparisons in head position, left shoulder position, and trunk lean remained unaffected by age ($F = 0.05$; $df = 1.00$; $P = .82$, $F = 0.82$; $df = 1.00$; $P = .37$, and $F = 1.9$; $df = 1.00$; $P = .18$, respectively).

Table 2

Characteristics of participants.

Characteristic	DHCPE (N = 12)	FTFE (N = 12)	Control (N = 12)	P
Age, years	15.08 ± 0.23	15.92 ± 0.23	15.08 ± 0.23	.020*
Sex, Male/Female	4/8	4/8	5/7	.887
Height, cm	164.53 ± 7.61	164.96 ± 6.83	161.78 ± 6.93	.503
Weight, kg	59.81 ± 16.50	61.72 ± 9.86	56.89 ± 10.53	.646
BMI, kg/m^2	21.86 ± 4.83	22.66 ± 3.31	21.73 ± 3.97	.835

Chi-square tests was used for sex, whereas ANOVA was applied to the other variables.
DHCPE = digital health corrective posture exercise, FTFE = face-to-face exercise.* $P < .05$.

4. Discussion

The primary objective of this study is to investigate the effects of a 6-week DHCPE program on head and shoulder posture in adolescents, utilizing a comprehensive evaluation across multiple planes, which can assess changes in the precise alignment of head and shoulder positions. Additionally, the evaluation examines the intervention's effects on adjacent points, such as the trunk and pelvis, while also assessing changes to check for the potential for postural compensatory mechanisms.[26–28] The findings indicate that DHCPE can significantly improve head and shoulder posture, demonstrating improvements comparable to those achieved with FTFE. These results highlight the potential effectiveness of DHCPE in promoting better postural alignment in adolescents.

Post-intervention, both the DHCPE and FTFE groups demonstrated significant improvements in head posture and protracted shoulder positions, indicating a decrease in FH and RS. Additionally, a significant negative change in trunk lean was observed, suggesting that the centers of the shoulder joints tilted backward around the hip joint, resulting in a straighter trunk posture. The simultaneous presence of shoulder retraction and an upright trunk position post-intervention indicates that the centers of the shoulder joints and trunk have shifted together toward a vertical alignment.[20] These enhancements suggest that the cervical and thoracic spine have been correctly realigned, facilitating better positioning of the head and shoulders.[29] A study demonstrated that a DHI utilizing a smartphone application for posture correction exercises reduced FH posture in young adults.[30] Another study found that an online corrective exercise intervention improved head and shoulder postures in adolescents.[31] Furthermore, a previous study has shown that a telerehabilitation exercise program aimed at correcting RS posture improved head posture, kyphosis angle, and shoulder angle in older adults.[32]

In our findings, both the DHCPE and FTFE groups demonstrated significant improvements in head and shoulder posture compared to the control group. One study also found that an online posture corrective exercise program significantly improved head and shoulder protrusions, as well as

Table 3

Comparison of posture parameters in the sagittal plane.

	DHCPE (N = 12)		FTFE (N = 12)		Control (N = 12)		Interaction effect	
	Pre	Post	Pre	Post	Pre	Post	Time by group	
Sagittal plane							*P* (*F*)	η²
HP, cm	4.61 ± 0.37	3.25 ± 0.75*	4.72 ± 0.38	3.18 ± 1.15*	4.79 ± 0.89	4.57 ± 0.67†,‡	*P* = .001 (*F* = 9.109)	0.356
Rt side PS, cm	3.12 ± 0.64	2.84 ± 0.66	2.93 ± 0.83	3.02 ± 0.82	3.17 ± 0.94	2.59 ± 0.53	*P* = .207 (*F* = 1.655)	0.091
Lt side PS, cm	3.32 ± 0.59	2.55 ± 0.74§	3.16 ± 0.61	2.64 ± 0.76‖	3.05 ± 0.47	3.22 ± 0.47¶,#	*P* = .031 (*F* = 3.868)	0.190
Rt side trunk lean, degree	-4.77 ± 2.06	-5.77 ± 1.40‖	-4.36 ± 1.43	-5.38 ± 1.30‖	-5.19 ± 0.78	-4.15 ± 1.06‖,¶,#	*P* = .001 (*F* = 8.978)	0.352
Lt side trunk lean, degree	-4.77 ± 2.06	-5.77 ± 1.40‖	-4.36 ± 1.43	-5.38 ± 1.30‖	-5.19 ± 0.78	-4.15 ± 1.06‖,¶,#	*P* = .001 (*F* = 8.978)	0.352

HP = head posture; PS = protracted shoulder.
* $P < .001$ between pre- and post-intervention.
† $P < .001$ between DHCPE and control.
‡ $P < .001$ between FTFE and control.
§ $P < .01$ between pre- and post-intervention.
‖ $P < .05$ between pre- and post-intervention.
¶ $P < .05$ between DHCPE and control.
\# $P < .05$ between FTFE and control.

Table 4

Comparison of posture parameters in the frontal plane.

	DHCPE (N = 12)		FTFE (N = 12)		Control (N = 12)		Interaction effect	
	Pre	Post	Pre	Post	Pre	Post	Time by group	
Frontal plane							*P* (*F*)	η2
Trunk deviation, cm	0.68 ± 0.43	0.81 ± 0.58	0.70 ± 0.28	0.88 ± 0.57	0.50 ± 0.37	0.49 ± 0.22	*P* = .707 (*F* = 0.350)	0.021
Rt side SL, cm	125.55 ± 6.75	127.16 ± 6.15*	125.38 ± 6.19	125.03 ± 5.97	122.91 ± 5.81	122.70 ± 5.74	*P* = .119 (*F* = 2.275)	0.121
Lt side SL, cm	124.66 ± 6.12	126.18 ± 5.90*	125.20 ± 5.85	125.17 ± 5.62	122.17 ± 6.26	122.02 ± 5.87	*P* = .215 (*F* = 1.608)	0.089
SL absolute difference, cm	1.06 ± 0.57	1.07 ± 0.84	0.75 ± 0.60	0.57 ± 0.44	0.92 ± 0.44	1.17 ± 0.76†	*P* = .406 (*F* = 0.928)	0.053
SL inequality, %	0.83 ± 0.39	0.83 ± 0.65	0.60 ± 0.48	0.45 ± 0.34	0.75 ± 0.38	0.97 ± 0.66†	*P* = .350 (*F* = 1.083)	0.062
Rt side PL, cm	77.61 ± 3.85	77.30 ± 2.90	77.61 ± 3.85	77.30 ± 2.90	75.68 ± 4.36	75.14 ± 4.07	*P* = .972 (*F* = 0.029)	0.002
Lt side PL, cm	77.10 ± 3.64	76.74 ± 2.96	75.93 ± 4.05	74.68 ± 3.87	75.31 ± 4.32	74.82 ± 4.35	*P* = .759 (*F* = 0.306)	0.017
PL absolute difference, cm	0.81 ± 0.45	0.80 ± 0.47	0.58 ± 0.50	0.63 ± 0.46	0.69 ± 0.34	0.47 ± 0.37	*P* = .398 (*F* = 0.948)	0.054
PL inequality, %	1.04 ± 0.56	1.04 ± 0.63	0.77 ± 0.68	0.83 ± 0.59	0.92 ± 0.45	0.64 ± 0.51	*P* = .400 (*F* = 0.941)	0.054

PL = pelvic level, SL = shoulder level.
* $P < .05$ between pre- and post-intervention.
† $P < .05$ between FTFE and control.

trunk tilt, in children and adolescents compared to the control group.[33] Moreover, the 2 interventions led to similar enhancements, aligning with previous research findings.[34] Furthermore, a DHI for correcting posture yielded improvements similar to those achieved through in-clinic therapist-led training for FH and RS.[12] Various studies have reported that, in addition to in-person treatments, digital interventions can also yield significant therapeutic effects.[11,13,35] We consider that designing appropriate exercise programs for promoting correct posture is essential for adolescents. For improving FH and RS in adolescents and young adults without musculoskeletal pathology, the most favored intervention approach is the structured design of appropriate stretching and strengthening exercises.[20,25,31,35] In particular, exercises such as sternocleidomastoid stretches, pectoralis stretches, chin tucks, and scapular retractions are supported by level 1b evidence, indicating a “good to excellent level” of effectiveness.[24] These intervention components were based on the programs implemented in this study. Specifically, both the DHCPE and FTFE groups utilized the same tailored intervention programs designed to address postural abnormalities without requiring direct physical contact from physical therapists such as manual therapy. Furthermore, the DHI can yield attendance and program adherence comparable to those of the FTFE, indicating its significance in enhancing the effectiveness of corrective posture exercises.[20,30,36] Considering the above, we believe that DHCPE may be an effective approach for improving head and shoulder posture in pain-free adolescents, even without the need for clinic visits. However, it is important to interpret the findings of this study involving adolescents with caution. In the assessment of trunk deviation, shoulder height, pelvic height, absolute differences, and inequality measured in the frontal plane, no significant group differences accompanied by interaction effects were found. These results may suggest that the improvements in head and shoulder posture post-intervention are not due to compensatory asymmetrical responses of adjacent joints and the trunk in the frontal plane. Although significant differences in age characteristics were found between the groups, the age variable did not appear to influence the findings of this study, as shown by the interaction results with age set as a covariate for head and shoulder posture. The findings of this study will aid in the design of appropriate DHI programs for pain-free adolescents at high risk of postural misalignments related to the head and shoulders, as well as in advancing various approaches to DHI without the need for clinic visits for treatment.

The limitations of this study are as follows. First, the relatively small sample size restricts the generalizability of the findings. Second, while the study was designed as a randomized controlled trial, it was conducted using cluster randomization rather than individual randomization, which may influence the interpretation of the results. Third, the lack of follow-up assessments prevents the evaluation of the sustained effects of the intervention. Fourth, there was a difference in age among the baseline characteristics of the groups; however, this did not directly impact the study’s results. Nonetheless, future research should ensure homogeneity between groups. In the control group, trunk lean deteriorated. We speculate that this may be due to the absence of any intervention, unlike the other groups. Therefore, it is likely that this deterioration reflects a natural postural change during adolescence, possibly influenced by extended periods of sedentary behavior in school environments.[37] Future studies should consider this possibility. Finally, there is an absence of X-ray data to assess the alignment of the cervical and thoracic spines in relation to head and shoulder posture. Including such data in future research would provide clearer insights into the impact of the intervention on postural alignment.

DHCPE and FTFE may be effective in improving head and shoulder posture in adolescents. The improvements associated with DHCPE are comparable to those achieved with FTFE. This suggests that DHCPE has the potential to serve as a viable alternative to FTFE for enhancing head and shoulder posture in this population.

Author contributions

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