ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/pediatr.2023-96298

# The Effect of Core Stabilization Exercises on Upper Extremity Motor Skills in Overweight and Obese Children: Quasi-Experimental Controlled Study

## Fazla Kilolu ve Obez Çocuklarda Kor Stabilizasyon Egzersizlerinin Üst Ekstremite Motor Becerileri Üzerine Etkisi: Yarı Deneysel Kontrollü Çalışma

Cemre Yaren GÜNGÖRENLER[a], Tülay TARSUSLU[b]

[a]Department of Physiotherapy and Rehabilitation, Yüksek İhtisas University Faculty of Health Science, Ankara, Türkiye
[b]Department of Neurological Rehabilitation, Dokuz Eylül University Faculty of Physical Therapy and Rehabilitation, İzmir, Türkiye

*This study was presented as a summary orally in İzmir Demokrasi University International Congress of Health Sciences 2022 (ICHES-IDU 2022) in October 21-22, 2022, İzmir, Türkiye.*

**ABSTRACT Objective:** This study was planned to investigate the effect of core stabilization exercises on upper extremity motor skills in overweight and obese children. **Material and Methods:** The study, which included obese, overweight and normal weight children, was designed as a quasi-experimental controlled study. An eight-week core stabilization exercise program was implemented to the children. In the first two-weeks of the eight-weeks exercise training, the children were taught how to stabilize the core region. Upper extremity motor skills were evaluated before-after the exercise program. The push-up test, grip strength measurement, Modified Closed Kinetic Chain Upper Extremity Stability Test (M-CKCUEST), Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form (BOT-2 SF), was used to evaluate upper extremity motor skills. SPSS 25.0 program was used for statistical analysis of the data. Significance level was determined as $p<0.05$. The normality distribution of continuous variables was evaluated with the Shapiro-Wilk test. When comparing the pre-test and post-test values, the dependent sample t-test was used if the data showed normal distribution, the Wilcoxon signed-rank test was used if it did not show normal distribution. **Results:** The study was completed with 46 children, 12 obese, 18 overweight, and 16 normal weight. Statistically significant improvement was obtained in the M-CKCUEST and BOT-2 SF subtests in obese children ($p<0.05$). In the overweight and normal weight children, there was a significant improvement in the push-up test, M-CKCUEST and BOT-2 SF subtests ($p<0.05$). No significant results were found in the inter-group analysis of all tests ($p>0.05$). **Conclusion:** Core stabilization exercises in overweight and obese children can improve upper extremity motor skills.

**Keywords:** Obesity; core stability; upper extremity

**ÖZET Amaç:** Bu çalışma, fazla kilolu ve obez çocuklarda kor stabilizasyon egzersizlerinin üst ekstremite motor becerilerine etkisini araştırmak amacıyla planlandı. **Gereç ve Yöntemler**: Obez, fazla kilolu ve normal kilolu çocukların dâhil edildiği çalışma yarı deneysel kontrollü bir çalışma olarak tasarlandı. Çocuklara 8 haftalık kor stabilizasyon egzersiz programı uygulandı. Sekiz haftalık egzersiz eğitiminin ilk iki haftasında çocuklara kor bölgesini nasıl stabilize edecekleri öğretildi. Egzersiz programı öncesi ve sonrası üst ekstremite motor becerileri değerlendirildi. Üst ekstremite motor becerilerini değerlendirmek için şınav testi, kavrama kuvveti ölçümü, Modifiye Kapalı Kinetik Zincir Üst Ekstremite Stabilite Testi (M-KKZÜEST), Bruininks-Oseretsky Motor Yeterlilik Testi-2 Kısa Form (BOT-2 KF) kullanıldı. Verilerin istatistiksel analizinde SPSS 25.0 programı kullanıldı. Anlamlılık düzeyi $p<0,05$ olarak belirlendi. Sürekli değişkenlerin normallik dağılımı Shapiro-Wilk testi ile değerlendirildi. Ön-test ve son-test değerlerinin karşılaştırılmasında, veriler normal dağılım gösteriyorsa bağımlı örneklem t-testi, normal dağılım göstermiyorsa Wilcoxon işaretli sıralar testi kullanıldı. **Bulgular:** Çalışma 12 obez, 18 fazla kilolu ve 16 normal kilolu olmak üzere 46 çocuk ile tamamlandı. Obez çocuklarda M-KKZÜEST ve BOT-2 KF alt testlerinde istatistiksel olarak anlamlı iyileşme elde edildi ($p<0,05$). Fazla kilolu ve normal kilolu çocuklarda şınav testi, M-KKZÜEST ve BOT-2 KF alt testlerinde anlamlı düzelme saptandı ($p<0,05$). Yapılan tüm testlerin gruplar arası analizinde anlamlı bir sonuç bulunamadı ($p>0,05$). **Sonuç:** Aşırı kilolu ve obez çocuklarda kor stabilizasyon egzersizleri üst ekstremite motor becerilerini geliştirebilir.

**Anahtar Kelimeler:** Obezite; kor stabilitesi; üst ekstremite

**Correspondence:** Cemre Yaren GÜNGÖRENLER
Department of Physiotherapy and Rehabilitation, Yüksek İhtisas University Faculty of Health Science, Ankara, Türkiye
**E-mail:** cyarengungorenler@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Pediatrics.

***Received:*** 23 Feb 2023 ***Accepted:*** 12 Jun 2023 ***Available online:*** 15 Jun 2023

Obesity is a public health problem that has increased from past to present and affects all societies.[1] According to the World Health Organization (WHO), overweight (OW) and obesity are defined as "abnormal or excessive fat accumulation that may impair health".[2] According to WHO 2016 data, it has been reported that the population of OW/obese (OB) children and adolescents between the ages of 5-19 is more than 340 million.[2]

Obesity affects all systems in our body. One of the systems most affected is the musculoskeletal system. Because carrying excessively increased fat mass in OB children damages both the biomechanical structure and functions of the musculoskeletal system. Obesity negatively affects functionally balance, coordination and basic motor skills.[1,3,4]

When compared to their healthy weight peers, OW and OB children have deficits in body coordination, coordination skills of extremities, basic motor skills (gross and fine motor skills), balance, postural control, strength and agility.[5,6] Studies also report that obesity in children has restrictive effects on fine motor skills such as upper extremity coordination and manual dexterity.[7,8]

The three-dimensional cylindrical structure formed by the lumbo-pelvic-hip complex, which is known as the center of the musculoskeletal system and wraps the body like a corset made up of muscles, is called the core region.[9-11] The most important task of the core region is to maintain the stability of the trunk and to ensure the formation of effective movements in the distal segments with proximal power generation.[9,10] The core region provides both postural control and fine-tuning of dexterous movements in the extremities. In the literature, it has been stated that the strength of the core region decreases with increasing body mass index (BMI).[12]

Based on the theories of anatomical connections, kinetic chain model, close connections of postural control and the upper extremity in the central nervous system, it is thought that there is a connection between upper extremity motor skills and core region.[11,13] Moreover, it is stated that trunk stability and control are improved with core stabilization exercises, thus postural stability is increased, resulting in skillful motor movements in the extremities.[14]

Considering all this literature, this study aims to investigate the effect of core stabilization exercises on upper extremity motor skills in OW and OB children.

## MATERIAL AND METHODS

The study was planned as a quasi-experimental controlled study conducted with normal weight (NW), OW and OB children aged 7-10 years who voluntarily agreed to participate in the study. The smallest sample size was calculated in the G*Power 3.1 (Heinrich-Heine-Universitat Düsseldorf, Germany) application with a 95% confidence interval, 80% power analysis using the static balance average values of a similar study conducted in 2019 by looking at the literature.[15] As a result of the calculations, the total number of NW, OW and OB children to be included in the study was determined as 45. Considering the loss in follow-up, it was aimed to reach 55 children in total. Children included in the study were divided into three groups as NW, OW and OB, based on percentile growth charts (2000 CDC Growth Charts) created according to age, gender and BMI determined by the Center for Disease Control and Prevention (CDC).[16] According to the CDC percentile growth tables, children with a percentile ≥95% were considered OB, children between ≥85% and <95% were OW, and children between 5% and <85% were NW.

Children aged 7-10 years, who gave their own and parental consent to participate, were included in the study. Having a percentile value <5% according to CDC's percentile growth tables, having an orthopedic problem that will limit exercises in the extremities, cervical region and trunk; had any injury or surgery in the past 6 months; had bariatric surgery; having neuro-motor diseases, chronic joint problems, psychiatric and severe cognitive problems were excluded. Consent of all participants and their parents to participate in the study was obtained with the Informed Consent Form prepared by the researchers. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Demographic characteristics such as age, gender, dominant extremity, body weight, height, BMI of children who met the inclusion criteria were collected. Children's grip strength was evaluated with a

hand dynamometer, upper extremity stabilization was evaluated with a modified form of Closed Kinetic Chain Upper Extremity Stabilization Test (M-CKCUEST), and upper extremity endurance was evaluated with push-up test. In addition, the upper extremity motor skills of the children were evaluated with the Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form (BOT-2 SF) subtests. Pre-test evaluations were made before starting the study. Core stabilization exercises for 45-60 minutes, three days a week for eight weeks, were applied to all children whose pre-test evaluations were completed successfully, under the supervision of a researcher. All participants who completed the eight-week exercise program were repeated evaluations before the exercises.

## EVALUATION METHODS

### Push-up Test

Children lay prone position on a hard floor. Arms shoulder-width apart, feet together and back in a neutral position. Push-ups were performed at a rhythm once every three seconds until the arms were flexed to 90°. Each correct push-up performed as described was rated as 1 point.[17]

### M-CKCUEST

Two lines were determined 91.4 cm apart on the stable ground. Between these two lines, the children's hands were directly under the shoulders, the male took the push-up position and the female took the modified push-up position. Hand changes were made by touching two lines 91.4 cm apart at maximum intensity within 15 seconds. The test was repeated 3 times with 45-second rest intervals. For the scoring of the test, the average of 3 hand changing was taken.[18]

### Grip Strength

Grip strength was assessed using a standard hand dynamometer (Baseline Hydraulic Hand Dynamometer, NY 10602 USA). During the test, the children were positioned in sitting position, shoulder adduction and neutral rotation, elbow 90º flexion, forearm mid-rotation. Three tests were performed for each extremity. Grip strength score was formed by taking the average of the three tests.[19]

### BOT-2 SF

The test consists of 8 subtests and 12 tasks. Dexterity, upper extremity coordination and bilateral coordination subtests were used in this study. The scores obtained during the test are the raw scores of the children. Then, these raw scores were converted into point scores for each item using the conversion scale.[20]

The Bilateral Coordination Subtest consists of the tasks of touching the tip of the nose with the index fingers and forming a square shape with the index and thumbs. Upper Extremity Coordination Subtest consists of catching the ball one-handed thrown from a distance of 3 meters and dribbling tasks. The Manual Dexterity Subtest consists of the task of stringing the blocks separately with both hands for a period of 15 seconds.

The exercise program consisted of warm-up exercises for 5 minutes, core stabilization exercise training for 45-60 minutes, three days a week for eight weeks, and then cooling exercises for 5 minutes. The eight-weeks exercise program were applied in two stages under the supervision of a researcher. In the first two weeks of the eight-week exercise program, diaphragmatic breathing and abdominal drawing-in maneuvers were performed in different positions (supine, crawling, sitting, standing, walking) in order to teach the children proper and controlled stabilization of the lumbopelvic region. Then, the remaining 6 weeks continued with exercises aimed at strengthening the core region. Core stabilization exercises applied to the children are presented in Table 1.

## ETHICS COMMITTEE APPROVAL

Ethics committee approval was obtained for the conduct of the research with the decision number 2021/10-36 of the Dokuz Eylül University Non-Interventional Research Ethics Committee dated March 29, 2021.

## STATISTICAL ANALYSIS

SPSS 25.0 program (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of the data. Significance level was determined as $p<0.05$. The normality distribution of continuous variables was evaluated with the Shapiro-Wilk test. Descriptive features were

**TABLE 1:** Exercises performed in the six weeks of exercise training.

| | 3-4 weeks | 5-6 weeks | 7-8 weeks |
|---|---|---|---|
| **Exercises** | **Number of set-number of repetition/time** | **Number of set-number of repetition/time** | **Number of set-number of repetition/time** |
| Cat/Cow stretch | 2 sets | 2 sets | 3 sets |
| Bird-Dog | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Press up | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Dead bug | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Sit up | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Medicine ball seated twist | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Prone plank | 2 sets-15 sec | 2 sets-20 sec | 3 sets-30 sec |
| Side plank | 2 sets-15 sec | 2 sets-20 sec | 3 sets-30 sec |
| Swimmer | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Superman | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |
| Russian twist | 2 sets-10 repetitions | 2 sets-15 repetitions | 3 sets-15 repetitions |

expressed as mean±standard deviation and median (minimum-maximum) for continuous variables, and numbers (n) and percentage (%) for categorical variables. In the comparison of the pre-test and post-test values of the intragroup data, the dependent sample t-test was used if the data showed normal distribution, the Wilcoxon signed-rank test was used if it did not show normal distribution.

In the comparison of the pre-test and post-test change differences of the inter-groups, the One-way ANOVA test was used if the data showed normal distribution, and the Games-Howell test was used to determine the group that caused the difference. Kruskal-Wallis test was used in the comparison of the pre-test and post-test change differences inter-groups, if the data did not show normal distribution, and the Bonferroni Corrected Mann-Whitney U test was used to determine the group that caused the difference.

## RESULTS

The study was completed with a total of 46 children, 16 female (34.8%) and 30 male 65.2%), with a mean age of 8.96±1.27 years. 26.1% of the children were OB (12), 39.1% were OW (18), and 34.8% were NW (16). While the number of right-hand dominant children was 44 (95.7%) the number of left-hand dominant children was 2 (4.3%). Other descriptive features of the children were presented in the Table 2.

Intragroup analysis of pre-test and post-test results of push-up test; while there was a statistically significant difference in the OW and NW children ($p<0.05$), no significant difference in the OB children

**TABLE 2:** Analysis of weight, height and BMI pretest and posttest findings.

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| | | **X̄±SD** | **Minimum-Maximum** | **X̄±SD** | **Minimum-Maximum** | **p value** |
| Obese group | Weight (kg) | 51.41±10.52 | 36.8-74.8 | 53.21±12.46 | 39.8-86 | 0.050 |
| | Height (m) | 1.41±0.1 | 1.18-1.53 | 1.42±0.1 | 1.2-1.57 | **0.006*** |
| | BMI (kg/m$^2$) | 25.77±2.71 | 22.21-31.95 | 26.03±3.5 | 21.94-35.11 | 0.433 |
| Overweight group | Weight (kg) | 34.48±6.49 | 22.4-46.3 | 34.67±6.69 | 21.8-47 | 0.532 |
| | Height (m) | 1.33±0.1 | 1.13-1.49 | 1.34±0.09 | 1.14-1.49 | **0.001*** |
| | BMI (kg/m$^2$) | 19.42±1.31 | 17.57-21.76 | 19.1±1.51 | 16.77-21.75 | 0.056 |
| Normal weight group | Weight (kg) | 30.31±7.58 | 9-44.8 | 30.92±7.34 | 20.9-45.4 | **0.011*** |
| | Height (m) | 1.34±0.12 | 1.16-1.56 | 1.35±0.12 | 1.17-1.56 | **0.003*** |
| | BMI (kg/m$^2$) | 16.5±1.52 | 13.79-18.78 | 16.66±1.33 | 14.5-18.87 | 0.265 |

*p<0.05; BMI: Body mass index; SD: Standard deviation.

(p>0.05). In the M-CKCUEST pre-test and post-test results showed a statistically significant difference in all groups (p<0.05). In the grip strength pre-test and post-test results didn't show a statistically significant difference for the three groups on both the right and left sides (p>0.05) (Table 3).

In the intragroup analyzes of the pre-test and post-test results of the bilateral coordination subtests in the OB group, while there was a statistically significant difference in the subtest of touching the tip of the nose with the index fingers, no significant difference in the subtest of forming a square with the index and thumbs. Statistically significant difference was found in both upper extremity coordination subtests and stringing the blocks test in the manual dexterity subtest (p<0.05, Table 4).

Statistically significant difference was found in both of the bilateral coordination subtests of the OW children. While there was a statistically significant difference in the upper extremity coordination dribbling subtest (p<0.05), no significant difference was found in the catching the ball subtest (p>0.05). Statistically significant difference was also found in the manual dexterity subtest (p<0.05) (Table 4).

Statistically significant difference was found in the intragroup analyzes of the pre-test and post-test results of the bilateral coordination subtests of the NW children (p<0.05). There was no statistically significant difference in upper extremity coordination subtests and manuel dexterity subtests (p>0.05) (Table 4).

There was no statistically significant difference in the analysis of push-up test, M-CKCUEST and grip strength (right and left sides) measurements, pre-test and post-test change differences inter-groups (p>0.05) (Table 5). There was no statistically significant difference in the analysis of the inter-groups, in the pre-test and post-test change differences in all subtests of BOT-2 SF (p>0.05) (Table 6).

## DISCUSSION

The results obtained from the study showed that core stabilization exercises affected upper extremity motor skills in OB, OW and NW children.

Looking at the push up test results, it was observed that OB children were more unsuccessful in push-up test performance than other two groups before the exercise. It has been determined that as the body weight increases, weight-bearing performance, including the upper extremities, is negatively affected in the prone position. The push-up test also requires good upper extremity muscle strength and stabilization of the trunk/shoulder girdle. The results obtained from the study suggest that low push-up performance may cause failure in growth and development performance characterized by deviations from normal in

**TABLE 3:** Intragroup analyzes of pretest and posttest findings of push up, M-CKCUEST and grip strength measurement tests.

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| | **Tests** | **(X̄±SD)** | **Median (minimum-maximum)** | **(X̄±SD)** | **Median (minimum-maximum)** | **p value** |
| Obese group | Push up test | 3±4.26 | 2 (0-15) | 4.08±6.07 | 2 (0-21) | 0.137 |
| | M-CKCUEST | 8.19±4.59 | 9.5 (0-13) | 10.03±5.07 | 11.33 (1.67-17.33) | **0.024*** |
| | Grip strength (right) | 20.06±4.26 | 20.17 (11.67-27.33) | 19.72±4.21 | 20 (12-27.67) | 0.359 |
| | Grip strength (left) | 18.89±4.05 | 20.33 (10.33-24) | 18.56±4.19 | 18.83 (10-24.33) | 0.610 |
| Overweight group | Push up test | 5.56±5.2 | 4 (0-17) | 8.78±8.36 | 6.5 (0-29) | **0.011*** |
| | M-CKCUEST | 10.91±4.58 | 11.17 (0.67-18.67) | 12.59±4.05 | 13 (3.67-20.33) | **0.009*** |
| | Grip strength (right) | 17.63±5.1 | 17.5 (9.33-29.33) | 18±5.31 | 17.33 (11-30.33) | 0.583 |
| | Grip strength (left) | 16.61±4.68 | 17.67 (8-26) | 17.37±5.21 | 17.83 (9.33-29) | 0.227 |
| Normal weight group | Push up test | 6.63±6.52 | 5 (0-20) | 11.5±10.24 | 8.5 (0-29) | **0.004*** |
| | M-CKCUEST | 12.08±2.95 | 12.33 (4.67-16.33) | 13.5±3.75 | 13.67 (7-19.33) | **0.006*** |
| | Grip strength (right) | 17.4±4.33 | 17.33 (10-25.33) | 17.31±5.97 | 16.17 (8.33-31) | 0.901 |
| | Grip strength (left) | 16.96±4.14 | 16.83 (10.67-24) | 17.38±5.76 | 15.33 (9-31) | 0.614 |

*p<0.05; M-CKCUEST: Modified closed kinetic chain upper extremity stability test; SD: Standard deviation.

**TABLE 4:** Intragroup analyzes of BOT-2 SF subtests pretest and posttest findings.

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| | **Tests** | **(X̄±SD)** | **Median (minimum-maximum)** | **(X̄±SD)** | **Median (minimum-maximum)** | **p value** |
| Obese group | *Bilateral Coordination ST* | | | | | |
| | Touch the tip of the nose | 3.21±0.89 | 3.5 (1-4) | 3.71±0.58 | 4 (2.5-4) | **0.016*** |
| | Forming a square shape | 4.54±0.4 | 4.5 (4-5) | 4.75±0.4 | 5 (4-5) | 0.096 |
| | *UE Coordination ST* | | | | | |
| | Catching the ball one-handed | 2.42±1.31 | 2 (1-4) | 3.58±1.38 | 4 (1-5) | **0.011*** |
| | Dribbling the ball. | 4.17±1.32 | 4 (2.5-6) | 4.96±1.71 | 5 (2.5-7) | **0.018*** |
| | *Manual Dexterity ST* | | | | | |
| | Stringing the blocks | 3.58±0.97 | 3.5 (2-5) | 4.21±0.89 | 4 (3-5.5) | **0.003*** |
| Overweight group | *Bilateral Coordination ST* | | | | | |
| | Touch the tip of the nose | 3.36±0.61 | 3.5 (2-4) | 3.81±0.3 | 4 (3-4) | **0.008*** |
| | Forming a square shape | 3.89±1.42 | 4.5 (0-5) | 4.42±1.19 | 5 (0-5) | **0.018*** |
| | *UE Coordination ST* | | | | | |
| | Catching the ball one-handed | 2.67±1.75 | 3 (0-5) | 3.06±1.73 | 3.5 (0-5) | 0.138 |
| | Dribbling the ball. | 4.92±1.84 | 5.25 (1.5-7) | 5.61±1.73 | 6.25 (2-7) | **0.003*** |
| | *Manual Dexterity ST* | | | | | |
| | Stringing the blocks | 3.28±1.09 | 3.5 (2-5) | 3.83±0.89 | 4 (2.5-5.5) | **0.008*** |
| Normal weight group | *Bilateral Coordination ST* | | | | | |
| | Touch the tip of the nose | 3.16±0.91 | 3.5 (1.5-4) | 3.56±0.75 | 4 (1.5-4) | **0.016*** |
| | Forming a square shape | 4.31±1.12 | 4.75 (1-5) | 4.94±0.17 | 5 (4.5-5) | **0.027*** |
| | *UE Coordination ST* | | | | | |
| | Catching the ball one-handed | 2.94±1.73 | 3 (0-5) | 3.19±1.83 | 4 (0-5) | 0.206 |
| | Dribbling the ball. | 4.66±1.8 | 5 (1-7) | 5.34±1.41 | 5 (3-7) | 0.059 |
| | *Manual Dexterity ST* | | | | | |
| | Stringing the blocks | 3.78±0.86 | 4 (2-5.5) | 4.06±0.98 | 4 (2.5-5.5) | 0.167 |

*p<0.05; M-CKCUEST: Modified closed kinetic chain upper extremity stability test; SD: Standard deviation.

**TABLE 5:** Inter-group analyzes of the change differences pre-test and post-test findings of push up test, M-CKCUEST and grip strength measurement.

| | Obese group | | Overweight group | | Normal weight group | | |
|---|---|---|---|---|---|---|---|
| | **(Pre test-Post test) X̄ (SD)** | **(Pre test-Post test) Median (minimum/maximum)** | **(Pre test-Post test) X̄ (SD)** | **(Pre test-Post test) Median (minimum/maximum)** | **(Pre test-Post test) X̄ (SD)** | **(Pre test-Post test) Median (minimum/maximum)** | **p value** |
| Push up test | 1.08 (2.23) | 0.5 (-2/6) | 3.22 (5.06) | 2 (-6/15) | 4.88 (6.7) | 1.5 (-1/19) | 0.251 |
| M-CKCUEST | 1.83 (2.42) | 1.67 (-1/7.67) | 1.69 (2.43) | 1.67 (-3.67/6.33) | 1.42 (1.76) | 1.83 (-3/4) | 0.986 |
| Grip strength (right) | -0.33 (1.21) | 0 (-3.33/1.33) | 0.37 (2.8) | 0.17 (-5/5.67) | -0.08 (2.65) | 0 (-5.33/5.67) | 0.650 |
| Grip strength (left) | -0.33 (2.2) | -0.17 (-4.67/3.67) | 0.76 (2.57) | 0.17 (-4/7) | 0.42 (3.24) | 0 (-5.33/7) | 0.477 |

*p<0.05; M-CKCUEST: Modified closed kinetic chain upper extremity stability test; SD: Standard deviation.

the growth curve in OB children, in activities that require standing up from the ground and pushing with the upper extremities in prone activities. Considering that increased body weight is not only related to standing and walking performance, but may also affect functional skills such as sitting on the floor, getting up from the ground, returning from the prone position to the supine position. The importance of having a healthy weight in children can be understood once again. In addition, activity and exercise practices aimed at increasing trunk stability and endurance will also contribute positively to push-up skills. As a matter of fact, in our study, it was observed that core stabilization exercises applied for

**TABLE 6:** Inter-group analyzes of the change differences pre-test and post-test findings of BOT-2 SF subtests.

| | Obese group | | Overweight group | | Normal weight group | | |
|---|---|---|---|---|---|---|---|
| | (Pre test-Post test) | (Pre test-Post test) Median | (Pre test-Post test) | (Pre test-Post test) Median | (Pre test-Post test) | (Pre test-Post test) Median | |
| | $\bar{X}$ (SD) | (minimum/maximum) | $\bar{X}$ (SD) | (minimum/maximum) | $\bar{X}$ (SD) | (minimum/maximum) | p value |
| *Bilateral Coordination ST* | | | | | | | |
| Touch the tip of the nose | 0.5 (0.52) | 0.5 (0/1.5) | 0.44 (0.59) | 0.5 (-0.5/1.5) | 0.41 (0.58) | 0 (0/2) | 0.806 |
| Forming a square shape | 0.21 (0.4) | 0 (-0.5/1) | 0.53 (0.88) | 0.25 (-0.5/3) | 0.63 (1.15) | 0 (0/4) | 0.773 |
| *UE Coordination ST* | | | | | | | |
| Catching the ball one-handed | 1.17 (1.12) | 1 (0/3) | 0.39 (1.04) | 0.5 (-2/2) | 0.25 (0.78) | 0 (-1/2) | 0.079 |
| Dribbling the ball. | 0.79 (0.99) | 0.75 (-1/2.5) | 0.69 (0.73) | 0.5 (-0.5/2) | 0.69 (1.29) | 0.25 (-1.5/3) | 0.839 |
| *Manual Dexterity ST* | | | | | | | |
| Stringing the blocks | 0.63 (0.57) | 0.5 (0/2) | 0.56 (0.76) | 0.5 (-0.5/2.5) | 0.28 (0.77) | 0 (-1/2) | 0.272 |

*p<0.05; BOT-2 SF: Bruininks-Oseretsky Test of Motor Proficiency-2 Short Form; ST: Subtest; UE: Upper extremity; SD: Standard deviation.

eight-weeks significantly improved push-up skills in children with NW and OW. When looking at the literature, it has been seen that core stabilization exercises provide improvements in the push up test in children and/or adolescents, consistent with our results.[21-23] Although a numerical increase was achieved in OB children in our study, a statistical significance was not reached. It is thought that these results may be due to the difficulty of OB children in taking and maintaining their starting positions, the negative effects of excessive weight gain on lifting the trunk from the ground and transporting time.

M-CKCUEST is a test that evaluates the functional performance of the shoulder, shoulder girdle and elbow, and also provides information about the strength, motor control and proprioceptive sense of the shoulder region.[24] Successful completion of the CKCUEST requires adequate core strength and stability.[25] In our study, it was observed that the core stabilization exercises significantly improved the results of M-CKCUEST in all groups. Lust et al. have applied six-weeks core stabilization exercises to young baseball players and achieved improvement in the CKCUEST results.[26] Additionally, when the results of M-CKCUEST were evaluated in our study, it was determined that OB children had less touch performance than OW and NW children and showed less improvement after exercise. Since the performance of the CKCUEST requires adequate shoulder-trunk stability and endurance, it was thought that this performance was lower in OB children at baseline values, which is reflected in these results. The results obtained from the push-up test values also support this findings.

Our results showed that core stabilization exercises had no statistically significant effect on grip strength, regardless of weight status. In a study conducted with athletic adolescents, it has observed that core stabilization exercises provided a significant improvement in left side grip strength results.[27] In another study, no improvements have observed in the grip strength of pilates exercises applied to children aged 5-6 years, consistent with the results of our study.[28] In a study comparing the grip strength of NW and OB adolescents, the grip strength results have found to be similar, but it has stated that the OB group had lower values in the expected grip strength percentages according to age and gender. This situation has interpreted in the study as it may be due to the losses in general muscle strength.[29] On the contrary in another study, it has stated that the grip strength of OW and OB individuals was higher than their NW peers.[30] Likewise, Deforche et al. showed that the grip strength has higher in OB children in their studies.[31] Looking at our results, when the mean values of grip strength were compared between the groups, it was observed that the grip strength measurement values of OW and NW children did not show a significant difference, while the mean grip strength of the both sides of the OB children was higher than the other two groups. This situation showed that OB children can be more successful in activities based on force in

the static position, which do not require dynamic and motor skills/coordination.

In a study, a relationship has found between Mcgill core stability tests and upper extremity motor skill tests.[32] It has been mentioned that a stronger core region provides a more effective force flow to the upper extremity by providing a stable trunk, therefore, to be more successful in upper extremity tests. Conversely, a weak core region can cause ineffective extremity movements.[32] In line with this hypothesis, improvements obtained from upper extremity motor skill measurements were evaluated as a result of core stabilization exercises in our study. Moreover, it is among the hypotheses in the literature that core stabilization exercises cause an increase in core muscle strength, but also increase neuromuscular facilitation, resulting in more dexterous movements in the extremities.[33] In the findings of our study, significant improvement in BOT-2 SF tests of OW and OB (including NW children in some BOT-2 SF subtests) children supports this hypothesis. In addition, considering the kinetic chain model, the improvements in the push-up and M-CKCUEST after core stabilization exercises suggest that core stabilization exercises contribute to the stability development of the shoulder complex, thus contributing to the formation of more dexterous motor activities in the distal extremity.

When the BOT-2 SF pre-test results were evaluated according to BMI status, OB children showed lower performance in catching the ball one-handed and dribbling tasks than other two groups. Although similar results were observed between the groups in the task of touching the tip of the nose, it was observed that the children with the lowest number of touching the tip of their nose in a coordinated way were OB children. In the bilateral coordination subtest forming square task, NW children performed higher than other two groups. It was noted that the most successful children in the manual dexterity subtest were also in the NW children. These results confirm the hypothesis that as BMI increases in children, there are more clumsy movements in upper extremity motor skills. Gentier et al. stated that obesity has a limiting effect on fine motor skills such as upper extremity coordination and dexterity.[8] In contrast, Marmeleira et al. in their study of children aged 6-10 years, they concluded that fine motor skills have relatively independent of increased BMI.[34] In another study conducted with OW and NW children aged 5-6 years, no statistically significant difference has found between the two groups in terms of fine motor skills.[35]

Although NW children were more successful in the pre-test of fine motor skills in our study, no significant difference was observed in the mean values between groups. Moreover, the significant improvements were seen only in the bilateral coordination subtests in the BOT-2 SF test in NW children. This results thought that the results obtained might have resulted from the fact that the test used to evaluate the relevant parameter was a simple test therefore the results of the evaluation were insufficient. The lack of assessment test/scale to be used in the assessment of fine motor skills in children aged 7-10 is mentioned in the literature, and it is stated that there is a need for tests to be developed specifically for the relevant age group.[34] Our results support the literature studies on this subject.

### LIMITATION

It was tried to reach more participants than the smallest sample size obtained as a result of the power analyzes made before starting the study. However, this aim could not be achieved because the research was carried out during the coronavirus disease-2019 pandemic. Due to the pandemic, there was a state of anxiety and panic in children and their parents about participation in the research, thus prolonging the data collection process.

## CONCLUSION

The results of our study showed that eight-week core stabilization exercises improved upper extremity motor skills in OW, OB and NW children. Although improvements were observed in upper extremity motor skills after core stabilization exercises applied in children with healthy weight, it was determined that core stabilization exercises were more effective in increasing upper extremity motor skills in OW and OB children compared to NW children.

### Source of Finance

*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*

### Conflict of Interest

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### Authorship Contributions

***Idea/Concept:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Design:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Control/Supervision:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Data Collection and/or Processing:*** *Cemre Yaren Güngörenler;* ***Analysis and/or Interpretation:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Literature Review:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Writing the Article:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Critical Review:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***References and Fundings:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu;* ***Materials:*** *Cemre Yaren Güngörenler, Tülay Tarsuslu.*

## REFERENCES

1. Greydanus DE, Agana M, Kamboj MK, Shebrain S, Soares N, Eke R, et al. Pediatric obesity: current concepts. Dis Mon. 2018;64(4):98-156. [Crossref] [PubMed]
2. World Health Organization. Obesity. Accessed June 20, 2023. [Link]
3. O'Malley GC, Shultz SP, Thivel D, Tsiros MD. Neuromusculoskeletal health in pediatric obesity: incorporating evidence into clinical examination. Curr Obes Rep. 2021;10(4):467-77. [Crossref] [PubMed] [PMC]
4. Merder-Coşkun D, Uzuner A, Keniş-Coşkun Ö, Çelenlioğlu AE, Akman M, Karadağ-Saygı E. Relationship between obesity and musculoskeletal system findings among children and adolescents. Turk J Phys Med Rehabil. 2017;63(3):207-14. [Crossref] [PubMed] [PMC]
5. Han A, Fu A, Cobley S, Sanders RH. Effectiveness of exercise intervention on improving fundamental movement skills and motor coordination in overweight/obese children and adolescents: a systematic review. J Sci Med Sport. 2018;21(1):89-102. [Crossref] [PubMed]
6. Gazbare P, Deshmukh S, Palekar TJ, Varghese N, Abraham B, Singh G, et al. Assessment of body coordination, strength and agility using Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) in overweight and obese children aged 7-12 years. Indian J Physiother Occup Ther. 2020;14(1):185-9. [Crossref]
7. Webster EK, Sur I, Stevens A, Robinson LE. Associations between body composition and fundamental motor skill competency in children. BMC Pediatr. 2021;21(1):444. [Crossref] [PubMed] [PMC]
8. Gentier I, D'Hondt E, Shultz S, Deforche B, Augustijn M, Hoorne S, et al. Fine and gross motor skills differ between healthy-weight and obese children. Res Dev Disabil. 2013;34(11):4043-51. [Crossref] [PubMed]
9. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med. 2006;36(3):189-98. [Crossref] [PubMed]
10. Barbara J. Hoogenboom KK. Core stabilization training. In: Brotzman SB, Manske RC, eds. Clinical Orthopaedic Rehabilitation: A Team Approach. 4th ed. Philadelphia: Elsevier; 2018. p.467-81.
11. Colston M. Core stability, part 1: overview of the concept. Athletic Therapy Today. 2012;17(1):8-13. [Crossref]
12. Milton JA, Martina AT. Correlation between body mass index and core muscular strength among school children between 11 and 14 years of age: a cross sectional study. Indian Journal of Physiotherapy & Occupational Therapy. 2019;13(3):196-200. [Crossref]
13. Silfies SP, Ebaugh D, Pontillo M, Butowicz CM. Critical review of the impact of core stability on upper extremity athletic injury and performance. Braz J Phys Ther. 2015;19(5):360-8. [Crossref] [PubMed] [PMC]
14. Bashir SF, Nuhmani S, Dhall R, Muaidi QI. Effect of core training on dynamic balance and agility among Indian junior tennis players. J Back Musculoskelet Rehabil. 2019;32(2):245-52. [Crossref] [PubMed]
15. Lengkana AS, Tangkudung J, Asmawi A. The effect of core stability exercise (CSE) on balance in primary school students. Journal of Education, Health and Sport. 2019;9(4):160-7. [Link]
16. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. 2000 CDC Growth Charts for the United States: methods and development. Vital Health Stat 11. 2002;(246):1-190. [PubMed]
17. Morrow JR Jr, Martin SB, Jackson AW. Reliability and validity of the FITNESSGRAM: quality of teacher-collected health-related fitness surveillance data. Res Q Exerc Sport. 2010;81(3 Suppl):S24-30. [Crossref] [PubMed]
18. Taylor JB, Wright AA, Smoliga JM, DePew JT, Hegedus EJ. Upper-extremity physical-performance tests in college athletes. J Sport Rehabil. 2016;25(2):146-54. [Crossref] [PubMed]
19. Balogun JA, Akomolafe CT, Amusa LO. Grip strength: effects of testing posture and elbow position. Arch Phys Med Rehabil. 1991;72(5):280-3. [PubMed]
20. Mülazımoğlu Ballı ÖM, Gürsoy F. Bruininks-Oseretsky Motor Yeterlik Testinin beş-altı yaş grubu Türk çocuklar için geçerlik ve güvenirlik çalışması [The study of validity and reliability of Bruininksoseretsky Motor Proficiency Test for five-six-years-old Turkish children]. Hacettepe J. of Sport Sciences. 2012;23(3):104-18. [Link]
21. Ji MY, Yoon JH, Song KJ, Oh JK. Effect of dry-land core training on physical fitness and swimming performance in adolescent elite swimmers. Iran J Public Health. 2021;50(3):540-9. [Crossref] [PubMed] [PMC]
22. Rahmat A, Naser H, Belal M, Hasan D. The effect of core stabilization exercises on the physical fitness in children 9-12 years. Journal of Romanian Sports Medicine Society. 2014;10(3):2401-5. [Link]
23. Boyacı A, Afyon Y. The effect of the core training to physical performance in children. Journal of Education and Practice. 2017;8(33):81-8. [Link]
24. de Oliveira VM, Pitangui AC, Nascimento VY, da Silva HA, Dos Passos MH, de Araújo RC. Test-retest reliability of the closed kinetic chain upper extremity stability test (CKCUEST) in adolescents: reliability of ckcuest in adolescents. Int J Sports Phys Ther. 2017;12(1):125-32. [PubMed] [PMC]
25. Callaway A, Peck J, Ellis S, Williams J. A randomised observational study of individualised variations in the start position of the closed-kinetic chain upper extremity stability test. Phys Ther Sport. 2020;41:16-22. [Crossref] [PubMed]

26. Lust KR, Sandrey MA, Bulger SM, Wilder N. The effects of 6-week training programs on throwing accuracy, proprioception, and core endurance in baseball. J Sport Rehabil. 2009;18(3):407-26. [Crossref] [PubMed]
27. Boyaci A, Tutar M, Biyikli T. The effect of dynamic and static core exercises on physical performance in children. European Journal of Physical Education and Sport. 2018;4(7):50-61. [Link]
28. Öztürk N. 5-6 yaş çocuklarında pilatesin postür ve fiziksel uygunluk parametrelerine etkisi: kontollü bir çalışma [Dokora tezi]. Denizli: Pamukkale Üniversitesi; 2020. Accessed 21 June 2023. [Link]
29. İskenderoğlu C. Obez ve sağlıklı adölesanlarda günlük yaşam aktiviteleri, fiziksel uygunluk ve yaşam kalitesinin karşılaştırılması [Yüksek lisans tezi]. Ankara: Hacettepe Üniversitesi; 2020. Accessed 21 June 2023. [Link]
30. Ervin RB, Fryar CD, Wang CY, Miller IM, Ogden CL. Strength and body weight in US children and adolescents. Pediatrics. 2014;134(3):e782-9. [Crossref] [PubMed] [PMC]
31. Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. Obes Res. 2003;11(3):434-41. [Crossref] [PubMed]
32. Nuhmani S. Correlation between core stability and upper-extremity performance in male collegiate athletes. Medicina (Kaunas). 2022;58(8):982. [Crossref] [PubMed] [PMC]
33. Miyake Y, Kobayashi R, Kelepecz D, Nakajima M. Core exercises elevate trunk stability to facilitate skilled motor behavior of the upper extremities. J Bodyw Mov Ther. 2013;17(2):259-65. [Crossref] [PubMed]
34. Marmeleira J, Veiga G, Cansado H, Raimundo A. Relationship between motor proficiency and body composition in 6- to 10-year-old children. J Paediatr Child Health. 2017;53(4):348-53. [Crossref] [PubMed]
35. Banjevic B, Aleksic D, Aleksic Veljkovic A, Katanic B, Masanovic B. Differences between healthy-weight and overweight serbian preschool children in motor and cognitive abilities. Int J Environ Res Public Health. 2022;19(18):11325. [Crossref] [PubMed] [PMC]