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# The Relationship Between Functional Level, Trunk Control, and Respiratory Functions in Children with Cerebral Palsy

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## ABSTRACT

Cerebral palsy (CP) is a developmental disorder characterized by a group of movement and posture problems that occur as a result of a lesion in the immature brain and affect the development of the brain. Our study aimed to examine and compare the functional level, trunk control, and respiratory functions in children with cerebral palsy (CP). There were a total of 61 children with CP, 51% female, and 49% male, with a mean age of 11.21±3.02 years. Demographic and disease-related information were evaluated with 'sociodemographic data form,' functional levels with the 'Gross Motor Function Classification System, trunk control with the 'Trunk Control Measurement Scale' (TCMS), and respiratory functions with 'the respiratory function test' using a spirometer. The functional levels of children with CP, 54% were Level 1, 26% were Level 2 and 20% were Level 3. In intergroup analysis, the mean trunk control of the children with Level 1 and 2 were statistically significantly higher than the children in Level 3 ($p<0.05$). Despite this, the children's FVC, $FEV_1$, PEF, $FEF_{25}$, $FEF_{75}$, $FEF_{25-75}$, and $FEV_1$/FVC parameters did not show significant statistical differences at functional levels ($p>0.05$). There was a positive low-level statistically significant correlation between the mean $FEV_1$ value and the scores of TCMS ($r=0.01$, $p<0.05$). On the other hand, no statistically significant correlation was found between trunk control and other respiratory function parameters ($p>0.05$). In children with CP, while trunk control increased as the functional level rose, there was no change in their respiratory functions.

**Keywords:** Cerebral palsy, respiratory function test, trunk control

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# Serebral Palsili Çocuklarda Fonksiyonel Seviye, Gövde Kontrolü ve Solunum Fonksiyonları Arasındaki İlişki


## ÖZ

Serebral Palsi (SP), immatür beyinde bir lezyon sonucu ortaya çıkan ve beynin gelişimini etkileyen, bir grup hareket ve postür problemleri ile karakterize gelişimsel bir bozukluktur. Çalışmamızın amacı, SP'li çocuklarda, fonksiyonel seviye, gövde kontrolü ve solunum fonksiyonlarının incelenmesi ve karşılaştırılmasıydı. Çalışmamıza, ortalama yaşları 11,21±3,02 yıl olan, %.51'i kız, %.49'u erkek, toplam 61 SP'li çocuk dahil edildi. Katılımcıların demografik ve hastalıkla ilgili bilgileri 'sosyodemografik veri formu' ile; fonksiyonel seviyeleri, "Kaba Motor Fonksiyon Sınıflandırma Sistemi" (KMFSS) ile; gövde kontrolü, "Gövde Kontrol Ölçüm Skalası" (GKÖS) ile; solunum fonksiyonları spirometre kullanılarak yapılan 'solunum fonksiyon testi' ile değerlendirildi. SP'li çocukların, %54'ü, Seviye 1; %26'sı, Seviye 2; %20'si, Seviye 3 içinde yer almaktaydı. Gruplar arası değerlendirmelerde, Seviye 1 ve 2'de yer alan çocukların gövde kontrolü, Seviye 3'te yer alan çocuklardan daha iyi düzeydeydi (p<0,05). Bununla birlikte, çocukların fonksiyonel seviyesine göre FVC, $FEV_1$, PEF, $FEF_{25}$, $FEF_{75}$, $FEF_{25-75}$, ve $FEV_1$/FVC parametreleri istatistiksel olarak anlamlı farklılık göstermedi (p>0,05). Gövde kontrolü ile birinci saniyede çıkarılan ekspirasyon hacmi (FEV1) arasında pozitif yönlü düşük düzey istatistiksel olarak anlamlı ilişki saptandı (r=0,01, p=0,05). Öte yandan, gövde kontrolü ile diğer solunum fonksiyonları parametreleri arasında istatistiksel olarak anlamlı düzeyde ilişki yoktu (p>0,05). SP'li çocuklarda, fonksiyonel seviye arttıkça gövde kontrolü artarken solunum fonksiyonlarında değişiklik görülmedi.


**Anahtar Sözcükler:** Gövde kontrolü, serebral palsi, solunum fonksiyon testi

## 1 Introduction

Cerebral Palsy (CP) is a developmental disorder characterized by movement and posture problems, which occurs because of damage to the immature brain and negatively affects its development (1). While 10–20% natal and 70–80% prenatal risk factors play a role in its etiology, there may be no risk factor in patients with 25% [1]. Children with CP may encounter issues such as muscle tone abnormalities, difficulty in activities that require coordination, neuromuscular deficits, lack of motor control, and other balance problems [1,2]. In addition to motor function problems such as abnormal muscle tone, gait, movement, and posture disorders, cognitive disorders, sensory disorders, and gastrointestinal and respiratory problems can also be seen in children with CP [2]. Depending on the severity of involvement, the muscle group on the affected side may be shorter and atrophic compared to the unaffected side in children with hemiparetic CP [3]. Such a difference in both halves of the body causes asymmetrical posture and difficulty in resisting gravity. As a result, trunk control may be affect worsen and balance problems arise [3]. The Gross Motor Function Classification System (GMFCS), which defines both disease severity and disease course, is used to classify motor impairment in children with CP. A high level of GMFCS indicates that the impairment in motor functions is severe [2]. A child at GMFCS III needs more support in ambulation than children at GMFCS I and II as he/she spends most of the day sitting. The trunk and antigravity muscles are weaker [2,3].

The trunk control provided by postural stability is the ability to keep the center of gravity within the support surface without any deterioration in balance [4]. The complex process that develops here varies depending on the commands and neuromuscular responses from the central nervous system, with the vestibular and visual systems also interacting [4]. Deficits in trunk control due to motor disability have been defined as one of the main problems seen in children's developmental stages [3,4]. The trunk control ability in children with CP is known to vary depending on the severity of the effect on the body. According to GMFCS, children with CP at levels 1 and 2 have less effective trunk involvement, while children with CP at levels 3, 4, and 5 have more effective trunk involvement [5]. Trunk control has been

reported to have a more adverse effect on quadriparetic children, and less so on diparetic and hemiparetic children [6]. Therefore, it should be kept in mind that weakened trunk control in CP may have an adverse effect on daily activities and motor functions [6,7].
Respiratory problems are substantial causes of morbidity and mortality and there are studies in the literature to evaluate respiratory functions in this population. These several studies have been performed including 6 studies by Kwon et al. who published 3 studies on the assessment of respiratory function according to GMFCS levels in different groups of children with CP [5, 8-10]. The abnormal respiratory pattern prompted by CP causes deterioration in motor developmental steps and inhibition of activities performed by children in daily life [8]. Therefore, it is a priority to include respiratory functions in routine clinical evaluations and to identify problems and take precautions with early therapeutic interventions [8, 11]. The poor coordination pattern that accompanies the respiratory muscles causes decreases in cardiopulmonary capacity and respiratory volume in children with CP who have respiratory problems [11]. In the study in which the respiratory function of children with diparetic and spastic hemiparetic CP was compared with healthy children, it was shown that there was a decrease in the respiratory capacity of children with CP and a statistical significance in FEV1, FVC, PEF values between the groups [12].
In the present study, we investigated and compare trunk control and respiratory functions of children with CP who we classified according to their functional levels. In addition, the study was to investigate the relationship between trunk control and respiratory functions in children.

## 2 Methodology

### 2.1 Participants and Study Design

To conduct the study, an application was submitted to the Health Sciences Research Ethics Committee of Istanbul Okan University, and upon obtaining its approval [29.12.2021-147], the study was conducted in accordance with the Helsinki declaration. 61 children who applied to the rehabilitation center, were diagnosed with CP, and met the inclusion criteria, participated in our study. All children included in the study and their families were given detailed information about the evaluations to be made in the study, and informed consent forms were obtained from them. All assessments were done face-to-face by physiotherapists. Children with CP included in our study were divided into three groups Level 1, Level 2, and Level 3 according to GMFCS.

While the inclusion criteria in our study were to be between the ages of 4 and 12, to be cooperative enough to understand the test directions, and to be at levels I, II, and III according to GMFCS, the exclusion criteria were the application of orthopedic surgery and/or botulinum toxin-A applied to the lower and/or upper extremities in the last 6 months, visual and hearing impairments that would prevent evaluations, congenital malformations accompanying CP, severe convulsions that cannot be controlled with drugs, to be at level IV, V according to GMFCS and to be in class III-IV (Classification of New York Heart Association).

### 2.2 Power analysis and sample size

In the study, a power analysis was applied with the help of a pilot study. Statistical power values were obtained with the help of the G*POWER software program during the application of pilot study power analysis. In a previous study, examined forced vital capacity (FVC) values by GMFCS [10]. Based on this, the effect size was calculated as 0.456 in the evaluation ($n^2$=0,456). Thus, a statistical power level of 81.4% was obtained for 51 people at the 5% significance level. Then, it was aimed to reach a minimum of 51 people in the study.

### 2.3 Assessments

The information related to the age, gender, demographic, and illnesses of the children was recorded with the 'participant evaluation form.' The functional motor levels of children with CP were determined according to the GMFCS, which consisted of 5 levels [13]. The levels can be summarized as follows: walk independently without restrictions at Level I, are accompanied by restrictions in the community at Level II, walk with support from their hands and with assistive devices at Level III, solo movement is limited and use assistive devices due to limitation at Level IV, and their head control is insufficient and is transported in a hand-push wheelchair at Level V [13].
The trunk control abilities of the children were evaluated using the Trunk Control Measurement Scale (TCMS) [14]. TCMS is a scale that scores the static and dynamic sitting balance responses of trunk control under 3 subtitles over 15 items. During the evaluation, the items were shown to the patient by hand following the explanation and clarification of each item verbally. Subsequently, the patient administered these substances on his/her own in three trials. In the evaluation of static sitting balance, the patient's realization of the movements of the upper and lower extremities was examined by paying attention to him/her standing upright without taking support from a place and the body's state of maintaining its static position was scored by items 1-5. The items 6-5 were scored and evaluated within the scope of dynamic sitting balance, selective motion control subscale and dynamic reaching subscale [14].
Pulmonary functions were evaluated by performing a pulmonary function test (PFT) with a spirometer device (PLUSMED PM-10) [15]. Dynamic lung volumes were measured with this test. During the spirometry test, nasal breathing was prevented by tightening the nose cartilage tightly while the child was sitting in an upright position. The test began with the child breathing into the spirometer mouthpiece at a normal tidal volume. Afterward, a continuous maximum expiration was requested for 3-6 seconds immediately following maximum inspiration. The children rested for 10 minutes before starting the test and the best measurement of the child was recorded as a result of the three measurements applied. Forced expiratory volume (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, peak expiratory flow (PEF) per second, and 25% flow of forced vital capacity (FEF25), the flow of 75% forced vital capacity (FEF75), forced 25% and 75% mean flow of vital capacity (FEF2575) values were measured [15].

### 2.4 Statistical analysis

SPPS 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical software was used to analyze the data. In the study, descriptive statistics were given for categorical and continuous variables. In addition, the homogeneity of the variances, one of the prerequisites of the parametric tests, was checked with the Levene test. The normality assumption was checked with the "Shapiro-Wilk" test. "Student's t-Test" was used in case the parametric test prerequisites were met and if not, the "Mann Whitney–U test" when intending to evaluate the differences between the two groups. The relationship between two continuous variables was evaluated with the Pearson Correlation Coefficient and, with the Spearman Correlation Coefficient if the parametric test prerequisites were not. $p<0.05$ level was considered statistically significant.

## 3 Results and Discussion

There were 71 children with CP who agreed to participate in the study, 6 of children were not suitable for the age range of 4-12 years and 4 of children who used botulinum toxin-A in the last 6 months were excluded from the study. The mean age, height, body weight and body mass index (BMI) values of sixty-one children with CP who participated in our study were 11.21±3.02 years, 147.66±15.80 cm, 44.32±14.92 kg, 29.35±7.80 kg/m$^2$, respectively. The mean age, height, body weight and body mass index (BMI) values of children according to functional level were shown in Table 1. According to the involvement state of the children, 8% of them were found to be ataxic CP, 30% to be diparetic CP, 3% to be dyskinetic CP, 12% to be quadriparetic CP, 26% to be right hemiparetic CP, and 21% to be left hemiparetic SP. The mean TCMS score of the participants was 49.03±9.60 points. 54% of children were in Level 1, 26% were in Level 2 and 20% were in Level 3 (Table 1).

**Table 1:** *Examination of the demographic and clinical characteristics of the participants (n=61)*

| | GMFCS | | | Stat. | P |
|---|---|---|---|---|---|
| | **Level 1 (n=33)** | **Level 2 (n=16)** | **Level 3 (n=12)** | | |
| | Mean±SD | Mean±SD | Mean±SD | | |
| Age (years) | 10.55±3.24 | 11.56±2.61 | 12.58±2.54 | 3.885 [1] | 0.143 |
| Height (cm) | 146.45±17.47 | 148.25±14.2 | 150.17±13.72 | 0.304 [1] | 0.859 |
| Weight (kg) | 42.2±15.66 | 47.06±15.54 | 46.5±11.92 | 1.797 [1] | 0.407 |
| BMI | 28.04±8.02 | 31.11±8.07 | 30.61±6.65 | 1.641 [1] | 0.440 |
| | | **N** | | **%** | |
| GMFCS | Level 1 | 33 | | 54 | |
| | Level 2 | 16 | | 26 | |
| | Level 3 | 12 | | 20 | |

Summary statistics were given as mean ± standard, minimum and maximum for continuous data and Number (Percentage) values for categorical data. BMI: Body Mass Index; CP: Cerebral Palsy

When trunk control and respiratory functions were compared according to the functional level of the participants, the mean trunk control of the children with Level 1 and 2 were statistically significantly higher than the children in Level 3 ($p<0.05$). Despite this, the children's FVC, $FEV_1$, PEF, $FEF_{25}$, $FEF_{75}$, $FEF_{25-75}$, and $FEV_1/FVC$ parameters did not show significant statistical differences at functional levels ($p>0.05$) (Table 2).

**Table 2*:*** *Comparison of trunk control and respiratory functions according to the functional level*

| | GMFCS | | | Test Stat. | p |
|---|---|---|---|---|---|
| | Level 1 (n=33) | Level 2 (n=16) | Level 3 (n=12) | | |
| | **Mean±SD** | **Mean±SD** | **Mean±SD** | | |
| FVC | 1.32±1.02 | 0.82±0.57 | 0.71±0.33 | 3.623 [1] | 0.163 |
| $FEV_1$ | 1.12±0.90 | 0.76±0.58 | 0.65±0.33 | 3.220 [1] | 0.200 |
| $FEV_1/FVC$ | 0.89±0.19 | 0.91±0.18 | 0.91±0.13 | 0.670 [1] | 0.715 |
| PEF | 2.21±1.19 | 1.78±0.84 | 1.92±1.30 | 1.307 [1] | 0.520 |
| $FEV_1$ (%) | 89.33±19.11 | 90.44±18.12 | 91.67±12.90 | 0.190 [1] | 0.910 |
| $FEF_{25}$ | 1.81±1.17 | 1.54±0.91 | 1.56±1.11 | 0.404 [1] | 0.817 |
| $FEF_{75}$ | 1.59±0.85 | 1.19±0.67 | 1.04±0.97 | 5.321 [1] | 0.070 |
| $FEF_{25-75}$ | 1.68±1.08 | 1.37±0.79 | 1.38±1.18 | 1.192 [1] | 0.551 |
| TCMS | 53.79±4.68 | 47.56±10.26 | 37.92±9.49 | 21.381 [1] | **0.001 **** |

*p<0,05; **p<0,01; [1]: Kruskal Wallis Test (H); Summary statistics were given as *mean ± standard* value for continuous data. a<b: Refers to a statistically significant difference of the distinct letter or letter combinations on the same line (p<0.05). FVC: Forced Vital Capacity, $FEV_1$: Forced Expiratory Volume, PEF: Peak Expiratory Flow, $FEV_{25}$: 25% Flow of Forced Vital Capacity, $FEF_{75}$: 75% Flow of Forced Vital Capacity, $FEF_{25-75}$: 25% and 75% Flow of Forced Vital Capacity

There was a positive low-level statistically significant correlation between the mean $FEV_1$ value and the scores of TCMS ($r=0.01$, $p<0.05$). On the other hand, no statistically significant correlation was found between trunk control and other respiratory function parameters ($p>0.05$) (Table 3). In addition, children with quadriparetic type CP had lower mean trunk control than other children with different involvements. The best mean TCMS was with right hemiparetic type SP and diparetic, and ataxic type CP followed it (53.19±5.42 points, 51.56±7.68 points, 51.40±4.10 points respectively) ($p<0.05$).

**Table 3:** *Correlation between the trunk control and the respiratory functions (n=61)*

| Respiratory Functions | TCMS |
|---|---|
| | r (p) |
| FVC | 0.229 (0.076) |
| $FEV_1$ | 0.274 **(0.032) *** |
| PEF | 0.161 (0.219) |
| $FEV_1$ (%) | -0.077 (0.558) |
| $FEF_{25}$ | 0.209 (0.105) |
| $FEF_{75}$ | 0.193 (0.137) |
| $FEF_{25-75}$ | 0.226 (0.080) |

*p<0,05; Pearson Correlation Coefficient. FVC: Forced Vital Capacity, $FEV_1$: Forced Expiratory Volume, PEF: Peak Expiratory Flow, $FEV_{25}$: 25% Flow of Forced Vital Capacity, $FEF_{75}$: 75% Flow of Forced Vital Capacity, $FEF_{25-75}$: 25% and 75% Flow of Forced Vital Capacity

In our study, while trunk control increased in children with CP as the functional level rose, no change was observed in their respiratory functions. Children with CP encountered issues in selective motor control deficiency, abnormal muscle tone, neuromuscular deficits, impaired coordination, and trunk control. These issues can cause limitations in the movements of children and balance disorders [16]. Heyrman et al., in a study in which they evaluated trunk control in children with CP with the TCMS scale, found that the children with CP had lower scores on all TCMS parameters compared to children of similar age with typical development [14]. In addition, they stated that the TCMS total score and the scores of all subscales differed according to the GMFCS levels, and there was a significant negative correlation between them [14]. In our study, too, children with quadriparetic CP, who was at Level 3 under GMFCS, had lower trunk control mean than other children with different involvements. Postural control is very important in sitting, walking, and balance activities to ensure proper trunk control in children with CP. Therefore, we think that children with quadriparetic CP with whole-body involvement have lower trunk control than children with Level 1 and Level 2 due to rigidity in their joints, collective movement of the body due to spasticity, and lack of postural and motor control. The results of our study supported the study of Heyrman et al.

In another study, Heyrman et al. evaluated the trunk controls of 100 children with CP whose levels ranged from 1 to 4 according to GMFCS, and of whom, 16 were quadriparetic CP, 38 were hemiparetic CP, 46 were diparetic CP, and compared the trunk controls of children with CP who had different involvements with each other [17]. As a result of this study, while the mean GMFCS score was 38.5 in CP types with different involvements, it was found to be 40 in diparetic CP, 44.5 in hemiparetic CP, and 13.5 in quadriparetic CP [18]. In all parameters, it was stated that the trunk controls of children with hemiparetic CP were better than children with diparetic and quadriparetic CP, and there was a negative correlation between the TCMS score and GMFCS [8, 9]. A high level of GMFCS indicates deterioration in motor function [14]. Therefore, an increase in the GMFCS level causes poor trunk control and inadequate balance reactions in children with CP. Although children at GMFCS Level 3 have the ability to control their trunks, they have weaker trunk control than children at GMFCS Levels 1 and 2 [17].

This result of our study was in line with those found in the literature. According to the GMFCS, children with Levels 1 and 2 have a higher trunk control mean than children with Level 3. Considering this situation, the mean trunk control of the children showed a statistically significant difference in functional levels. Trunk control is one of the basic components of postural control. Various problems accompany the movement and posture development of children with CP, and they experience difficulties while trying to maintain trunk control [18]. It has been pointed out in the studies included in the literature that there is a great difference between children with CP and regular individuals when evaluated in terms of trunk control, and trunk involvement of children with CP posed a serious problem [17]. It was seen when examining the TCMS results of the study that these children have trunk effects and that children with spastic hemiparetic type CP have better scores between static sitting, dynamic sitting, and selective motor control total scores compared to children with CP with diparetic involvement [4,19]. These studies have shown that lack of trunk control causes a significant motor impairment in CP and negatively affects children's activities of daily everyday life [18, 20]. Although respiratory problems were a vital cause of morbidity and mortality in children with CP, few studies have been conducted on the reference value of respiratory functions in the literature [20]. Therefore, a prompt diagnosis of respiratory function issues is quite crucial for clinical evaluation and early remedial intervention [20]. In respiratory evaluations performed in children with CP, FEV1 and FVC capacities were low as restrictive patterns developed. In these children, respiratory functions were adversely affected by the weakening of muscles that help stabilize trunk control such as rectus abdominis, internal and external abdominal muscles, and transversus abdominis which were especially effective in forced expiratory capacity. Therefore, there was a significant correlation between the FEV1 value of these children and their trunk controls. While the expiratory muscles that help breathing increased the mechanical advantage of the diaphragm, which forms the roof of the core region, and helped the trunk control, their strain during forced expiration while coughing indicated that these muscles were weak.

Studies conducted with children with CP in the literature showed that respiratory problems could be observed at different rates depending on the severity of involvement in children with CP [19]. In a study comparing the respiratory functions of children with diparetic type CP and children with spastic hemiparetic CP with healthy children, Kwon et al. observed a decrease in respiratory functions of children in general, and showed a statistically significant difference between diparetic and spastic hemiparetic CP children in terms of FEV1, FVC and PEF values in favor of children with spastic hemiparetic CP [8]. Kwon et al., in their study in 2013, compared children with spastic hemiparetic and diparetic type CP in terms of respiratory functions and chest circumference measurement. 19 diparetic and 10 hemiparetic children were included in the study [8]. It was stated as a result of the study that the children with spastic hemiparetic CP performed better than diparetic children in terms of respiratory muscle strength, FEV1, and FVC [20]. While evaluating respiratory functions in the literature, we discovered that most studies examined spastic hemiparetic and diparetic type CP to improve the child's both oral motor and cognitive aspects. Therefore, we think that the respiratory functions of children with CP who have different types of involvement should be examined in detail in future studies. Children with CP have poor muscle strength throughout the body, including respiratory muscles, their airway secretions are not properly removed due to spasms, and therefore, abnormal respiratory functions can be seen in them [20].

## 4 Conclusions

In conclusion, in our study, in which we examined the relationship between trunk control and respiratory functions in accordance with the functional level in children with CP, it was concluded that TCMS and spirometry measurements could be added to the outcome measures used in clinical practice and that evaluations for respiratory parameters should not be ignored. The results of comprehensive evaluation criteria for physiotherapists provide valuable data in determining the accurate treatment goals, creating individual treatment programs for the needs of the children, and demonstrating the effectiveness of the treatments.

## 5 Declarations

### 5.1 Study Limitations

The limitations of our study include the inability to use devices that objectively evaluate muscle tone, 3-dimensional gait analysis, or electromyographic systems in the evaluation of trunk control as current clinical conditions are not suitable, and the inability to evaluate respiratory muscle strength in addition to the evaluation of respiratory functions.

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### 5.3 Funding source

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### 5.4 Competing Interests

There is no conflict of interest in this study.

### 5.5 Authors' Contributions

**Corresponding Author Gamze AYDIN,** had made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

**Author Didem GÜNDÜZ** had made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

## 6 Human and Animal Related Study

If the work involves the use of human/animal subjects, each manuscript should contain the following subheadings under this section.

### 6.1 Ethical Approval

Ethical approval for this study was obtained from Social and Non-Interventional Health Sciences Research Ethics Committee of Istanbul Okan University (IRB study protocol: 29.12.2021-147).

### 6.2 Informed Consent

Informed consent form was obtained from all participants for the study that they agreed to participate in the study.

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