T.C.
YEDITEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

THE RELATIONSHIP BETWEEN HEAD MOVEMENT IN SAGITTAL PLANE AND THE UPPER EXTREMITY FUNCTION IN CHILDREN WITH SPASTIC CEREBRAL PALSY

MASTER THESIS

Ezgi KOYUNCU, PT

İstanbul-2020

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THESIS APPROVAL FORM

TEZ ONAYI FORMU

Kurum : Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü

Program : Fizyoterapi ve Rehabilitasyon Bölümü

Tez Başlığı : The Relationship Between Head Movement in Sagittal Plane and The Upper Extremity Function in Children with Spastic Cerebral Palsy

Tez Sahibi : Ezgi Koyuncu

Sınav Tarihi : 24.01.2020

Bu çalışma jurimiz tarafından kapsam ve kalite yönünden Yüksek Lisans Tezi olarak kabul edilmiştir.

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun 07/02/2020 tarih ve 2020/02-21 sayılı kararı ile onaylanmıştır.

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for award of any other degree except where due acknowledgment has been made in the text.

Ezgi KOYUNCU

DEDICATION

I would like to dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving mother Figen FERT, my grandmother Emel FERT and grandfather Ali FERT.

ACKNOWLEDGEMENT

I would like to express my special thanks to my Adviser Çigdem YAZICI MUTLU, who continually provided me all support and guidance which made this project possible. I am extremely grateful to her for providing these opportunities.

I would like to express my deep gratitude to Feride BILIR, for her patient guidance, for her believing in me and continuously encouraging and supporting me. Your drive, perfectionism and enthusiasm for pediatric research has definitely taught and inspired me.

In addition, I can not forget my friends; Merve YILMAZ MENEK, Ayça YAĞCIOĞLU and Durukal TAŞ who went through the hard times together with me. Thank you for your support and for the many hours we have spent sitting next to each other.

Finally, my deep and sincere gratitude to my family for their continuous help and support, I am forever thankful to my mother Figen FERT and grandfather Ali FERT for giving me the opportunities and experiences that have made me who I am.

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LIST OF SYMBOLS AND ABBREVIATIONS

CP: Cerebral Palsy

GMFCS: Gross Motor Function Classification System

ICF: International Classification of Functioning, Disability and Health

HMSP: Head Movement in Sagittal Plane

ROM: Range of Motion

RT: Reaction Time

QUEST: Quality of Upper Extremities Skills Test

TCMS: The Trunk Control Measurement Scale

TMSP: Trunk Movement in Sagittal Plane

ABSTRACT

Koyuncu, E. (2020). The Relationship Between Head Movement in Sagittal Plane and The Upper Extremity Function in Children with Spastic Cerebral Palsy, Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

The aim of our study was to investigate the relationship between head movement in sagittal plane and quality of upper extremities in children with spastic CP. The 32 spastic CP children aged from 3 to 12 years in the I-III level according to the Gross Motor Functional Classification System (GMFCS) were included in the study. The demographic features of children (gender, birth date, body height, body weight, health problems) were recorded as per the informations had been provided by respective parents of the children. Trunk control was evaluated with Trunk Control Measurement Scale (TCMS), quality of upper extremities functions were evaluated with Quality of Upper Extremity Skills Test (QUEST), and head movement in sagittal plane was observed with Coach Eye's application. Moreover, gross motor functions were classified according to Gross Motor Function Classification System (GMFCS). According to the results of the study, there was a negative correlation between head movement in sagittal plane and upper extremities functions in hemiparetic and diparetic CP ($p<0.05$). However, there was also negatice correlation between head movement in sagittal plane and upper extremities functions in tetraparetic CP, but it was not statically significant important ($p \geq 0.05$). Additionally, there was a negative correlation between trunk control and head movement in hemiparetic and diparetic CP ($p <0,05$), whereas not correlation in tetraparetic CP ($p \geq 0.05$).

Key Words: cerebral palsy, head movement, upper extremity functions, trunk control

ÖZET

Koyuncu, E. Serebral Palsili Çocuklarda Sagital Düzlemdeki Baş Hareketi ile Üst Ekstremite Fonksiyonları Arasındaki İlişkisi, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi. İstanbul.
Bu çalışmanın amacı, serebral palsi tanısı almış çocuklarda başın sagital düzlemdeki hareketi ile üst ekstiremite fonksiyonelliği arasındaki ilişkiyi incelemektir. Çalışmaya yaşları 3 ile 12 arasında bulunan ve kaba motor fonksiyon sınıflandırma sistemine göre Seviye 1 ile Seviye 3 arasında olan 32 spastik serebral palsili çocuk katılmıştır. Çocukların demografik özellikleri (cinsiyet, doğum tarihi, boy, kilo, sağlık problemleri) ailelerinden gelen bilgilerle kayıt altına alınmıştır. Gövde Kontrol Ölçüm Skalası (TCMS) ile gövde kontrolü ve Üst Ekstremite Becerilerinin Kalitesi Testi (QUEST) ile ekstremite fonksiyonlarının kalitesi değerlendirilmiştir. Başın sagital düzlemdeki hareketi ise Coach Eye's mobil uygulamasıyla ölçülmüştür. Bu değerlendirmelere ek olarak, çocuğun kaba motor fonksiyon seviyesi Kaba Motor Fonksiyon Sınıflama Sistemi (GMFCS) ile sınıflandırılmıştır. Çalışmamızın sonuçlarına göre; hemiparetik ve diparetik serebral palsili çocuklarda başın sagital düzlemdeki hareketi ile üst ekstiremite becerileri arasında ters ilişki bulunmuştur ($p<0.05$). Fakat, tetraparetik çocuklarda negatif bir ilişki bulunsa bile istatiksel olarak anlamlı değildir ($p \geq 0.05$). Ayrıca; hemiparetik ve diparetik tip serebral palsili çocuklarda, gövde kontrolü ile başın sagital düzlemdeki hareketi arasında ters ilişki bulunmuşken ($p<0.05$), tetraparetik çocuklarda anamlı ilişki bulunmamıştır ($p \geq 0.05$) .

Anahtar kelimeler: serebral palsi, baş hareketi, üst ekstiremite fonksiyonu, gövde kontrolü

1. INTRODUCTION AND PURPOSE

Cerebral palsy (CP) is the one of the most common permanent motor disabilities seen in the childhood (1). Movement, posture and activity limitations are the motor disabilities caused by brain damage at prenatal, natal or postnatal terms of child. Motor disabilities can occur as a result of weakness of muscles, abnormal muscle tonus, orthopedic problems, abnormal reflex activities, insufficient trunk and head control (2, 3). Additionally, children with CP often show other neurodevepmental disorders or impairments such as a sensational, perceptional, cognitional, communican and behavioral disorders (4).

During locomotion the upper body and lower extremity have different goals. The lower extremity's aim is mobility and translation of body and, the upper body's aim is to maintain the balance in response to the moving of lower extremity. Therefore trunk and head can be characterized as a stable system in dynamic equilibrium (5).

Trunk and head controls play a key role in executing daily living activities. Trunk control is important because inadequate trunk controls does not provide balance reactions and stable base of support for limbs and head which is necessary for the quality motion (6). In addition, trunk control takes part in controlled movement against gravity and body position for balance reaction and functions (7).

Head control which starts to develop in the first four months of life, is a precondition for the development of locomotor skills and motor abilities such as grasping, sitting and reaching (8). Because of the presence of many sensory systems in head, stabilization of the head during locomotor activities plays an important role due to the locomotion. The stabilized head position in space allows for the adjustment of sensory systems and trunk-head coordination for optimal functions (9). With the sudden movement of head, visual and vestibular receptors are stimulated and these receptors contribute motor and postural controls for activities. Furthermore, head movement is also important for visual control of task performance (10). Considering all these reasons, it is understood that providing head control is important to perform daily living activities.

Previous studies have demonstrated that head movements increase more in children with CP than in healthy children during inter-position transfers, lying down, sitting, at all stages of walking and even short and fast movements of the eye.Thus, increased frequency of antagonist activation, increased number of muscles recruited, increased sway and a tendency for rostral to caudal muscle recruitment are required to provide stability (11,12).

Inadequate trunk and head control which is resulting from fixation deficiencies, abnormal changes in muscle tone, inadequate reciprocal innervation and abnormal coordination also effect functioning of upper extremities (13). The movements of the upper extremity vary depending on the position in terms of speed and quality. Therefore, the development of head stability and control is considered as an one of the prerequisite for upper extremity functions and hand use (14). In summary, maintaining stability during dynamic equilibrium and stabilization in upright position is the primary task of the head and trunk during the movement of child.

Regarding these reasons, the aim of the study is to find the relationship between the movement of the head in the sagittal plane and the functions of the upper extremity in children with CP. The hypothesisof this study are following:

Hypothesis 0 (H0): There is no relationship between upper extremity functions and movement of the head in the sagittal plane in children with CP.

Hypothesis 1 (H1): There is a relationship between upper extremity functions and movement of the head in the sagittal plane in children with CP.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The term CP was first used by William Little in the 1840s. Although many researchers have studied the definition of CP, it always have been a challenge define it. Recently, CP can be defined as an umbrella term that includes motor dysfunction and multiple comorbidities. CP occurs as a result of the brain damage in the prenatal, natal and postanal term and these insults can lead to hypoxic events, congenital brain malformations, and infections (15).

Furthermore, CP is a permanent condition; whatever it might be, neither resolves nor progresses and it is characterized by abnormal maturation of central nervous system, (spasticity and persistence of primitive reflexes), cognitive impairment and sensory impairments (16,17). All these factors act on abnormal muscle tone, muscle weakness, abnormal postural control, orthopedic problems, abnormal movement patterns and asymmetry.

Finally, severity of damage is variable among the children. For this reason, motor disabilities, sensory and cognitive impairments are also highly varies and the frequency of these associated disabilities varies according to the specific type of CP and the responsible etiologic factor (18).

2.1. Epidemiology of CP

The studies to determine the prevalence of cerebral palsy demonstrated that rate of prevalence in Europe is between 1.51-2.2/1000, in the USA is between 1.7-2.0/1000 and in China to be 1,28-1,92/1000 (19,20). A research where conducted in Turkey showed that prevalence rate is between 2-8/1000 among 2-16 years children with CP. Although Turkey has high prevalence rate than developed countries, the etiology is generally similar (21).

2.2. Etiology and Risk Factors of CP

The studies showed that cerebral palsy formation can not be defined exactly because CP is effected by multiple reasons and it is very diverse. Developing brain may be exposed to harmful factors in prenatal, natal or postanal term. These factors can be genetic, congenital or acquired such as inflammatory, infectious, anoxic, traumatic and metabolic (22).

Risk factors can be divided into 3 subgroups according to the period the brain is damaged:

Prenatal risk factors

•intrauterine infections

•placental complication

•multiple births

•teratogenic exposures

•maternal conditions

Perinatal risk factors

•infections

•intracranial hemorrhage

•hypoglycemia

•seizures

•hyperbilirubinemia

•birth asphyxia

Postnatal risk factors

•toxic

•infectious meningitis

•encephalitis

•trauma (23).

Prematurity is (≤ 34 weeks) the one of the most significant risk factor, although the presence of early high technology diagnostic procedures can prevent to CP. Alternatively, the risk factors which is most seen are prenatal injuries and low birth weight (≤1500 gr) with respect to gestatinonal age. Insufficient intrauterine growth, respiratory problems (prolonged ventilation, pneumothorax, sepsis, hyponatremia, etc…) and genetic malformations can also lead to CP (24,25).

2.3. Diagnosis

In the treatment of cerebral palsy, early diagnosis and early intervention are important. In addition to laboratory testing and neuroimaging, clinical assessment is the fundamental tool which helps to diagnose cerebral palsy. In clinical assessment, the clinician observes the child and asks to family about the child's milestones such as such as rolling, sitting, standing, and walking. On the other hand, the clinician examines child's posture, deep tendon reflexes, and muscle tone and abnormal neurological signs that are acceptable during the first year but after a certain time clinician expects to resolve them (26).

Neuroimaging techniques such as ultrasound and magnetic resonance also can be used to defining the CP. They can provide the detection of the hazard that has effect on the central nervous system in early life (27).

2.4. Classification of CP

For the evaluation of child with CP, classification of the type of CP is important to decide on an effective treatment plan and to set short and long term goals for the child. Moreover, the classification system explains the functional status and future prognosis of the child. Until recently, therapists have used more complicated classification system which included anatomical region of the brain lesion, clinical symptoms, time of damage, muscle tone and topographic involvement of extremities (28). For this reason, The Surveillance of Cerebral Palsy in Europe eliminated such complexity and introduced a new classification system. With this classification, cerebral palsy is divided into two groups as physiological and topographical (29).

2.4.1. Physiological classification of spastic CP

In a physiological classification system, it is important to determine which region of a developing brain is affected. Different motor symptoms develop depending on the affected area. If the corticospinal tract (pyramidal) is affected; spastic type is observed. If the other tract, (extrapyramidal) is affected; athetoid, ataxic, and hypotonic CP occur (30).

Physiologic classification consists of the types of CP:

- spastic,
- dyskinetic (which includes dystonia and choreoathetosis),
- ataxic
- hypotonic
- mixed (Table 2.1).

Table 2.1. Physiological classification of cerebral palsy (31).

Types	Description
Spastic	Velocity-dependent increase in muscle tone with passive stretch and joint contractures are common.
Dyskinetic	Purposeless movements are common but, joint contractures are uncommon.
Ataxic	Disturbance of coordinated movement and they have low muscle tone. Most commonly they are walking and they have normal head/neck control.
Hypotonic	They have low muscle tone and normal deep tendon reflex.
Mixed	They have features of more than one type and no head/neck control.

2.4.1.1. Spastic type CP

Spastic CP is the most common form (70% to 80) of CP. Spastic CP is characterised with increased muscle tone, persistence of primitive reflexes and hiperreflexia (31, 32). In the children with spastic CP, the difficulty to start and terminate the movement is seen due to the abnormal control of muscles between agonist and antagonist muscle activity. Moreover, increased suprasegmental reflexes inhibit protective extansor, balance and protective reaction which are needed for the postural control and ambulation during the lifetime (33).

In these children, spasticity most commonly affects the shoulder extensors, adductors, internal rotators, elbow flexors, pronators and wrist flexors in the upper extremities. Also, in the lower extremities hip flexors, adductors, internal rotators, knee flexors and ankle flexors are much more affected.

The most common problems in children with spastic CP are:

- spasticity in the extremities
- decreased muscle tonus in trunk
- stereotypic movement pattern
- slow motion
- associated reactions
- joint deformities, posture and gait disorders due to muscle weakness (34).

2.4.1.2. Dyskinetic type CP

Another common type (15% to 20%) after spastic cerebral palsy is dyskinetic CP. It is characterized with fluctuating muscular tone and hypertonia. In dyskinetic CP, damage to the basal ganglion and thalamus lead to involuntary, recurring, uncontrolled, and occasionally stereotyped movements (35). Dystonia and choreoathetosis types also accompany the dyskinetic CP. In dystonic type, because of the involuntary muscle co-contraction and hypertonia, permanent or intermittent, twisting movement is seen in the trunk and extremities. In choreoathetotic type, hypotonia is the reason behind the proximal and distal hyperkinetic movements (36).

The most common problems in children with dyskinetic CP are :

- varying in muscle tone
- involuntary movements in the extremities and trunk
- insufficiency of trunk and extremities stabilization
- insufficiency of balance and protective reactions (33).

In addition to motor problems, some cognitive problems accompany as well. The impairment in thalamus and basal ganglion has negative effects on attention and executive function (37).

2.4.1.3. Ataxic type CP

This type is seen in 4% of children with CP (38). Ataxic CP is caused by cerebellum deficits and is usually associated with spasticity and athetosis (29). Moreover, it is also defined as impairment in kinesthetic sensation, balance and incoordination. The first symptom before the child starts walking is hypotonia. Muscle weakness, Rebound Phenomenon, nystagmus, explosive talking, dynamic tremor or mental retardation can also be observed.

<u>The most common problems in children with ataxic CP are:</u>

- dysmetria
- insufficient co-contraction
- hypotonia and rarely increased muscle tone
- insufficient postural stabilization
- coordination disorder in movements (34).

2.4.1.4. Hypotonic CP

In the children with hypotonic CP, there is no normal and sufficient contraction and relaxation in muscle. It is usually transition phase between development of athetosis and spasticity. Inadequate muscle tone and stretching reflexes, decreased primitif reflexes or joint laxity are also seen.

<u>The most common problems in children with ataxic CP are:</u>

- insufficient head control
- joint hypermobility
- weak stabilization and control of trunk.

2.4.1.5. Mixed CP

It is composed of spastic, dystonic and athetoid movements (33).

2.4.2. Topographic classification of spastic CP

Depending on the affected parts of the body, topographic classification of CP can be divided into 5 subtypes:

Monoparetic, hemiparetic, triparetic, diparetic and tetraparetic CP (Table 2.2).

In hemiparetic CP the same side of the body is affected. The upper extremities are involved rather than lower extremities. Children with hemiparetic CP have some impairments such as fine motor and grasping difficulties, stereognosis, two point discrimination and sensational problems (23).

Diparetic CP is emerged by low birth weight and prematurity. Generally, periventricular leukomalacia (PVL) causes ischemic brain injury which is one of the cause of diparetic CP. In this type, lower extremities are involved more than upper extremities. Children with diparetic CP have toe walking, seizures, nystagmus, stabilization problems, strabismus and scissoring of legs because of the adductor spasticity (23).

Tetraparetic CP is occurred as a result of an acute hypoxic intrapartum asphyxia but it is not the only reason to tetraparetic CP (8). Four limbs are affected and the upper part of the body is more severely affected than the lower part of the body. Furthermore, voluntary movement disorder is common due to the vasomotor changes of the extremities and most of these children have swallowing and aspiration problems (39, 40).

Table 2.2. Topographic classification of spastic cerebral palsy (31).

Types	Description
Monoplegia	One extremity involved, usually lower
Hemiplegia	Both extremities on same side involved Usually upper extremity involved more than lower extremity
Diplegia	Lower extremities more involved than upper extremities Fine-motor/sensory abnormalities in upper extremity
Triplegia	Both arm and a leg or both legs and an arm
Quadriplegia	All extremities involved equally Normal head/neck control

2.5. Associate Manifestations and Complications of Spastic CP

2.5.1. Mental retardation

It is noteworthy that children with CP usually have mental retardation as a result of social and physical risk factors. Physical risk factors include; low levels of physical activity, sleep disorders, and pain. For instance; children with CP have physical problems and speech difficulties which lead to less participation to recreational activities than typically developing children. Apart from physical factors, social factors such as social environment, quality of life and self-concept also have impacts on mental health. For example; friendship is particularly important for the development of a subjective well-being of children with CP, thus it reduces the risk of mental health disorders. Therefore, all of these risk factors elevate the mental health disorder prevalence (41,42).

2.5.2. Epilepsy

Epilepsy is one of the common problems seen in children with CP (%25 to 45%). It is a clearly observed that there is a closed relationship between brain injury and epilepsy. Hence, it can affect academic achievement, self-esteem, behavioral and general health, physical activities and quality life of children with CP (43). Consequently, identification or preventing the adverse effects of epilepsy are important to make an effective treatment plan.

2.5.3. Visual impairment

Recently, several studies have shown that there is a correlation between vision impairments and cognition, motor skills, daily living activities, communication and self-care in children with CP. As a result of the brain damage or peripheral visual structures damage, the visual-perceptual problems are emerged. For instance, damage in the primary visual pathway eye, (optic nerves, thalami, optic radiations, and primary visual cortices), in the visual association areas, or the oculomotor system can affect visual abilities. Hence, a therapist should have a knowledge on how the child performs in vision-related activities before planning the therapy (44, 45).

2.5.4. Hearing problems

The auditory system can be referred to as a normal pathway for learning and development of speech by using auditory skills. Auditory skills are important for the development of an oral language, speech production has effect on motor tasks and so is external auditory cueing. Any disorders of higher cortical function can lead to changes in articulation, speech, fluency and prosody. These problems can be eliminated or reduced by speech therapy or devices such as cochlear implant (46).

2.5.5. Speech and languages disorders

Nearly, 20% of children with CP have intelligible speech problem, despite the fact that 50% of them have less speech and communication problems. Difficulties in speech and language can arise from impaired neuromuscular control of speech mechanism (i.e. dysarthria), cognitive and ⁄or sensory processing deficits. And, most studies report that language plays a role in cognitive and executive skills (47).

2.5.6. Sleep Disorder

Children with CP have disturbed sleep patterns. The quality of sleep depends on whether they have epilepsy, muscle spasms, type of musculoskeletal pain, drugs and body position. The visual impairment and blindness can also affect duration and maintenance of sleep as the melatonin hormone is secreted by hypothalamus which is stimulated with visual receptors in the darkness. And, melatonin hormone is related to timing and maintenance of sleep (48).

2.5.7. Feeding

Insufficient oral motor, cognitive and manual skills lead to feeding difficulties among children with CP. Mostly, poor coordination of swallowing and chewing are seen resulting from upper motor neuron disorders which lead to malnutrition. Negative effects of poor feeding are growth problems and unhealthy nutritional status that decrease children’s quality of life. Decently, feeding increases children’s life expectancy whereas obesity decreases the children’s quality of life (49).

2.5.8. Respiratory problem

Generally, 40% of children with CP suffer from respiratory problems. The children with the foregoing have abnormal muscle tone, muscle contraction and unstable postural control, because of the brain damage which not only negatively affects the the movement but also respiration. For instance, with insufficient trunk control, the ribcage’s alignment is broken and ribcage can not be expanded in the anterior, posterior and lateral direction which causes respiratory problems as postural control muscles, especially abdominal and trunk muscles, actively contract during the respiration circle.

Additionally, diaphragm is unable the adjust the pressure between thoracic and abdominal cavities, so it ends up working much harder and gets tired quickly which causes respiratory problems (50).

2.5.9. Bladder dysfunction- bowel dysfunction

Incontinence, urinary urgency, infections and constipation are most common problems in CP. Insufficient feeding or water intake and mobility may increase the risk for the development of these problems. Moreover, spasticity has effect on detrusor muscles so, it leads to irritable bladder. On the other hand, mental retardation and motor deficit can also be associated with incontinence and bladder dysfunctions (51).

2.6. Upper Extremity Functions

Upper extremity skills are important for independent living and essential for daily living activities such as self-care, work, leisure, household routines and social communication. These activities include gross, fine motor movements and cooperation of them with upper extremities (52, 53).

2.6.1. Development of upper extremity functions

Voluntary grasping is a skill that emerges in the first 4 months of life which can be defined as the ability of child to close all the fingers around an object at the same time. Before the first 4 months, automatic grasping reflex is observed by a stimulus contact to palm and all fingers take a flexion position. After a series of grasping experience, precision grip grasping between the tips of the thumb and index finger occurs in the 10 months (54).

Reaching nearly begins at 3 months of age. During this period, the clumps reaching progressively being replaced with purposeful reaching without successful grasping. At 6 months, reaching kinematics develops and children start to embrace straight reaching movement. A number of studies show that many factors affect the quality of reaching such as proprioception, visual perception, neuromuscular forces and stabilization of trunk and head (55).

Reaction time (RT) is the period between stimulation and the beginning of the voluntary response. Voluntary movements require much more time in comparison to the reflex movement. Also, RT is changeable according to the amount of the information to decide the movement. If the child knows to answer needed for the movement, RT is fast. The more complicated tasks are added, the more RT is gets slow. Moreover, with the growing of child grow up, RT gets faster, especially in around 8-9 years of life. At the 16- 17 ages, RT reaches the adult's RT (56).

2.6.2. Upper extremity function in children with spastic CP

The upper extremity problems are commonly seen in spastic CP due to anormal coordination, insufficient movement, visual, perceptional and sensorial problems. In addition, inadequate protective reactions, balance reactions and body stabilization negatively affect upper extremities functions. For instance, it may lead to inability to perform manual activities such as grasp, releasing and manipulation of objects. The dominant hand is used for manipulation while, non-dominant hand is used for stabilization during activities. (57).

The children with CP can exhibit abnormal reaching pattern and can have a restricted range of motion (ROM) in the upper extremities. Their lack of ROM can be caused by spasticity or contracture. Generally, typical upper limb posture is seen in spastic CP can be described as internal rotation of the shoulder, flexion of elbow, pronation of elbow, flexion of wrist and fingers and adduction of thumb. For example, reaching quality is variable as the reduced shoulder elevation affects the total time required to complete the reach or grip cycles and the path taken by the hand (57,58).

Previous studies have demonstrated that children with CP not only have motor impairments but also have, somatosensory problems. The closed relationship between sensory and motor systems can contribute to upper limb dysfunctions. Especially, tactile sensibility on fine motor skills are impaired in CP (59).

In summary, children who are forced to use their hands simultaneously for selective movements, reaching and grasping; develop strategy and inappropriate pattern. Therefore, the treatment plan should include improving both unimanual and bimanual symmetric functions.

2.7. Development of Head Control

Head control starts to increasingly develop between two and three months. In fact, early head movements are seen between the two and eight weeks and the first head movements are rotations to the left and right. After, infants learn to keep the position of their heads in the midline position, especially in the crying period because of neck muscles are activated by crying. And head control continues to dramatically improve in the first year and throughout life (60).

2.7.1. Head movements during locomotor tasks

Recent researches suggest that upper limbs aim is providing a stable system in upright position while lower limbs are moving. During locomotor tasks, the head is one of the parts of this stabilization. Head control contributes to a stable frame for the organization of the respective limbs and the environment (61). For example, there must be an inter-joint and intersegment coordination between the head and the trunk during goal-oriented reaching. The head and trunk control provides a stable position against the sudden oscillations caused by the movement of the arms.

Moreover, head control has a significant role in dynamic balance during activities. In response to head on trunks movements, head control provides a stable head position in space (62). Studies of head on trunk movement have shown that the more limitation is experienced during locomotor tasks as the task gets harder (63).

On the other part, the head is the location of the visual and vestibular system, so head control can be considered critical for visual orientation and balance. There is a relationship between vision and control of head in space. For vision, head stabilizes the gaze so images are stabilized in retina and interpretation of image information gets easier. For instance, the normal sequence of reaching includes firstly orientation of gaze, then head and finally using of arm in the proper direction (62, 64).

Not only there is a relationship between vision and head movement, the vestibular system and head movement are also interlinked. Vestibular impairments are one of the causes of the unstabil posture of the body and abnormal changes in the alignment of head posture (65).

It is also clearly known that vestibular and proprioceptive systems have effects on control of head movement while walking. As a result of changes in these systems, compensatory movements are observed. Compensatory movements such as head rotation or changes in head angular velocity provide to maintain head stabilization on the trunk. For example in the sagittal plane, the child use head rotation to compensate trunk displacement while walking. If the child walks on an inclined surface, the position of the head in space is adjusted as a result of otoliths information. For this reason, researchers assume that head movements are under vestibular control for the reorganization of trunk movements and body adaptations (66).

2.7.2. Head Movements in children with CP

Children with spastic CP often exhibit insufficient head control or head instability in daily living activities. Deficits in vestibular, proprioceptive and visual system, trunk control and abnormal muscle activities are among reasons of abnormal head movements.

Previous studies indicated that increased head movement is observed in children with CP during transitions between postures, reaching and even eye movements than normally developed children as. These children often have difficulties in the righting reaction of the head so, they are unable to control head posture which are occured along and around the body axis (67,68).

In addition, head stabilization is crucial for walking, sitting and upper limb activities in children with CP. During dynamic tasks, the muscle must be recruited in a certain order against to an external perturbation. Thus, a child can exhibit motor strategies to maintain a stable position which is important for anticipation and adaptation of balance during activities. The role of head movements during the emergence of motor strategies is to establish spatial orientation, to provide stabilized visual field, head angular velocity and accelerations. However, head and trunk control is weak in children with CP according to the site and degree of brain damage (69, 70).

2.8. Management of CP

A multidisciplinary treatment program plays an important role in achieving maximum independence of the children. Orthopedists, neurologists, physiatrists, physical therapists, occupational therapists, speech therapist and psychologist must be involved in a multidisciplinary team. In addition, while making a treatment plan neural plasticity, degree of brain damage, the welfare of the family and intervention’s aim must be considered by the therapist (71, 72).

Many different methods are used in the treatment of cerebral palsy such as traditional physiotherapy, botulinum toxin injections, surgeries and medical treatments. The main goals of traditional physiotherapy are to increase muscle strength, joint movements, reduce muscle spasticity and pathological reflexes. Additionally, static and dynamic muscle stretching can be applied for the prevention of joint limitations.

Another method is a neurodevelopment treatment which is founded by Berta and Karl Bobath which is also known as Bobath Method. The main purpose of this method is to promote normal motor development and to prevent additional limitations and problems such as contracture, abnormal posture and reflexes.

In addition to physiotherapy, sensory integration and occupational therapy are essential for children with CP. Sensory integration therapy facilitates functional activities by using sensory networks and prevent sensory integration disorders such as sensory discrimination and impaired sensory modulation. In sensory integration therapy, the sensory network which includes visual, auditory and perceptual clues are used. Furthermore, combination of sensory integration and occupational therapy can improve the quality life of children by providing self-care activities. The quality of life is improved by changing the environment in which the child is located and adapting the vehicles to the child (73).

3. MATERIAL AND METHOD

3.1. Participants

This study was managed with spastic cerebral palsy children who were chosen from Ribem Riskli Bebek Danışma Merkezi (Appendix 1.) to investigate the relationship between head motion in sagittal plane and upper extremity functions. The observations were made between March 2019 and October 2019. This study was approved by Yeditepe University Clinical Research Ethics Committee (Appendix 2 NO: 975, 28.02.2019).

The following criterias have 40 children with CP who were included in the study.

3.1.1. Inclusion criterias

- Children should have spastic serebral palsy diagnose
- Children had not major intellectual deficit and had to be able to follow verbal instructions.
- Gross Motor Function Classification System (GMFCS) levels were measured and children who had level 1, 2, 3 were accepted the study
- Children were chosen between 3-12 years old

3.1.2. Exclution criterias were determined as

- Children who had contracture
- Children must not undergo botulinum toxin injections and orthopedic surgey in the last year
- Children who had unstable medical problems and seizures

3.1.3. Flow Chart: Study Protocol (Table 3.1.)

All parents were informed about the study before the start of the assessment and, signatures were taken (Appendix 3.). These parents answered some questions about the socioeconomic and demographic characteristics of their children such as age, gender, height, body weight, dominant hand and other information. The form that includes information about child's general health status and demographic features is filled by therapist by asking parents in Turkish language (Appendix 4.).

The assessments started with gross motor functions and after classifications, children's trunk control (TCMS) (Appendix 5.), quality of upper extremities functions (QUEST) (Appendix 6.) and head motion (Coach Eye's App) were evaluated.

Table 3.1. Flow chart of study

Selection of children with spastic cerebral palsy who are receiving treatment from the Ribem Center between July and September 2019.
(n = 40)

↓

Because of cognition problems, some children did not complete the all tests and they are excluded. (n= 8)

↓

Interventions
(n=32)
Socioeconomics and Demographic Characteristics
The Gross Motor Function Classification System (GMFCS)
The Trunk Control Measurement Scale (TCMS)
Quality of Upper Extremity Skills Test (QUEST)
Coach Eye's Application

3.2. Evaluations

3.2.1. The Gross Motor Function Classification System (GMFCS)

The purpose of GMFCS is to evaluate gross motor abilities of CP children. It includes 5 levels and each level is separated as development level by 0-2, 2-4, 4-6, 6-12 and 12-18 age of children. Functional limitations increase from level 1 (least limitations) to level 5 (Table 3.2.). According to this classification system, the therapist observes children's mobility type, walking, walking distance, sitting, body support and external supports (orthoses, walker and wheelchair) (74,75).

Table 3.2. Gross motor Function Classification System (GMFCS)

Level I
0-2 ages: Childs starts to learn to sit, crawling and use both hand to play and manipulate objects. **2-4 ages:** Child successfully sitting without support and may start to standing and walking. **4-6 ages:** Child sits and stands up form chair without support, walk freely, climbs stairs and begin to run and jump. **6-12/ 12-18 ages:** Child can walk and climb stairs without limitations. Coordination, speed and balance are affected.
Level II
0-2 ages: Child begins to sit with adult or their hands support and may craw by using hands and knee or on belly. **2-4 ages:** Child can sit but may have balance problem, especially when they use their hands. They can walk with devices or holding objects (furnitures). **4-6 ages:** Child sits without assistance, but need support for standing to moving. Walking without limitataions and climbs stairs holding onto a railing. **6-12 ages:** There are limitations walking on uneven surface and inclines and walking in crowd space. They may have problem when carrying objects. **12-18 ages:** Individual walk in most setting, but environmental and personal factors can impact mobility choices. Can walk up and down stairs using the railing or with assistance
Level III
0-2 ages: Child can roll and creep on stomach but need back support while sitting position. **2-4 ages**: Child sit without support on the floor and alos, can crawl on hands and knees. **4-6 ages:** Child can sit on a chair and can lift himself form chair with hand support. Child can walk indoors with assisstive mobility devices. **6-12 ages:** Child may able to climb stairs without adult assistance but with the use of handrails and uses wheeled devices to move long distances. **12-18 ages:** Individual can walk with handheld devices and transfers require physical assistance from others. May need a seatbelt for alignment and balance.
Level IV
0-2 ages: Infant has head control, but the entire truck must be supported for floor sitting. **2-4 ages:** Child can floor sit when placed in a sitting position, but is unable to stay balanced without using hands for support. **4-6 ages:** Child needs adaptive seating to sit and may walk short distances with a walker and help from others. **6-12 ages:** Child uses powered mobility or needs physical assistance to move in most settings. Requires adaptive seating for control and balance and needs help with most transfers. **12-18 ages:** Individuals use wheeled mobility and require adaptive seating for pelvic and trunk control. Indoors individual may walk short distances with physical assistance or use wheelchair.
Level V
0-2 ages: Child unable to maintain head or trunk control in prone or supine postures. Need assistances. **2- 18 ages:** Child can not move independently. Child has not trunk and head control and not be able to maintain upright position. Child’s all areas of motor function are limited.

3.2.2. The Trunk Control Measurement Scale (TCMS)

Postural and trunk control are weak in children with CP. As a result of weak trunk control, functional sitting balance is also not enough to provide stabilization of the body during movement and selective movements. Understanding of impairment in trunk control is important because of this The Trunk Control Measurement Scale (TCMS) was found to assess trunk control of children with CP by Heyrman and his coworkers (76).

TCMS has 15 items and measures static (20 scores) (Figure 3.1.) and dynamic (38 scores) control of the trunk. Dynamic sitting balance is divided into selective movement control (28 scores) (Figure 3.2.) and dynamic extending (18 scores) (Figure 3.3.). At the end of the test, the child can get a minumum 0 score and maximum 58 scores. As a result the test, higher test score indicate better trunk control.

During the test, the therapist removed external support materials such as orthosis, body corset, and splint if the child have. All the children sat on a bench with no back, hand and feet support. Each items are administired bilaterally. Scoring was done using 0-4 scale. The best of the three performances were marked.

Figure 3.1. Static trunk control

Figure 3.2. Dynamic selective trunk control

Figure 3.3. Reaching dynamic trunk control

Table 3. 3. The Trunk Control Measurement Scale (TCMS) (77).

STATIC SITTING BALANCE	
1	Unsupported upright sitting for 10 seconds.
2	Lifting both arms at eye level and sitting.
3	Therapist crosses one leg over the other leg.
4	Child crosses one leg over the other leg.
5	Children abducts one leg over 10 cm and returns to starting position.
DYNAMIC SITTING BALANCE	
6	Leaning forwad approximately 45 degree flexion of trunk and return to starting position.
7	Leaning backward approximately 45 degree extension of trunk and return to starting position.
8	Touching the table with elbow at level of the femoral head.
9	Lifting the pelvis at one side and return to starting position.
10	Rotating the upper trunk three times with head fixated in starting position.
11	Rotating the lower trunk three times with head fixated in starting
12	Shuffling the pelvis three times in a forward direction and return backwards in three times to the starting position.
13	Reaching forward with both arms straight to target at eye level.
14	Reaching sideward with one arm straight to target at eye level
15	Reaching across the midline with one arm (reach to the opposite side) and return to starting.

3.2.3. Quality of Upper Extremity Skills Test (QUEST)

Quality of Upper Extremity Skills Test (QUEST) is used as a clinic tool to measure movement patterns of upper extremities and hand functions of children. QUEST can be utilized with children aged 18 months to 8 years old. Dissociated movement, grasp, protective extension and weight bearing are classified based on QUEST. It also includes hand spasticity, function and child's cooperation ability. However, in our study we did not evaluate these three sections of QUEST. It includes 33 activity item and each items are calculated by using special formulas (Appendix 6). When scoring produce is finished, the minimum score is 0, the maximum score is 100 (Table 3.4).

Table 3.4. Quality of Upper Extremity Skills Test (QUEST) (78,79) .

Domains of the QUEST			
A. Dissociated Movements	**B.Grasp**	**C. Weight Bearing**	**D. Protective Extension**
Shoulder ▪ Flexion ▪ Flexion with fingers extended ▪ Abduction ▪ Abduction with figers extended **Elbow** ▪ Flexion with supination ▪ Extension with supination ▪ Flexion with pronation ▪ Extension with pronation **Wrist** ▪ Extension with elbow extension ▪ Extension with elbow flexion ▪ Extension with pronation ▪ Extension with supination ▪ Flexion with supination **Independent movements** ▪ Fingers ▪ Thumb	▪ Grasp of cube ▪ Grasp of cereal ▪ Grasp of pencil	▪ Weight bearing in prone ▪ Weight bearing in prone with reach ▪ Weight bearing in sitting with hands forward ▪ Weight bearing in sitting with hands by side ▪ Weight bearing in sitting with hands behind	▪ Protective extension - forward ▪ Protective extension-side ▪ Protective extension-backwards

3.2.3.1. QUEST procedure

The subscale 'dissociated movement' measures the performance of isolated shoulder, elbow and wrist motions and record the range of motions (Figure 3.4.). While movements were observing, elbow and wrist positions must be recorded. The grasp subscale evaluates child's ability to hold objects which the shape of objects looks like cube, pencil and cereal. During these two assessments, child should sit bench with feet support. Head, shoulder and trunk posture are part of criteria (Figure 3.5.).

In the weight bearing section, the child's position is prone or four-point kneelling on the floor or mat. Child must keep the position at least two seconds. If the child able to keep position, clinician asks the child to raise one hand. Then, the clinician observes whether child achieves or does not (Figure 3.6.).

At the examination of protective extension, the child's start position is ring sitting or kneeling. As a result of the changes in weight bearing, rapid displacement of the center of gravity is observed. While testing, full elbow extension or flexion, hands and fingers position are noticed (Figure 3.7.).

In our study, we did not evaluate child's muscle spasticity, hand function and cooperation which are part of the QUEST test.

Figure 3.4. Dissociated movements

Figure 3.5. Grasping

Figure 3.6. Protective extension

Figure 3.7. Weight bearing

3.2.4. Coach's Eye video analysis application

Coach's Eye is an advanced video recording system that connects directly to the camera on a smartphone or tablet. It allows clinicians to slow down and pin-point analysis for patient's movements. Additionally, the application provides the ability to take a note to remember at particular points of time and compare videos side by side.

3.2.6.1.Video Analysis procedure

Before the starting video record, the therapist should remove the any external supports if the child has (orthoses, splints, body corset and kinesiotape). During the evaluation, the child must sit on a bench with feet support but without back support. Firstly, the end of the noise, trochanter major and tragus were detected for being reference points and using these three points nature head(Figure 3.8.) and trunk positions(Figure 3.9.) of the child was calculated. After that child was asked to reach an object where placed away from 90% of the child’s arm length. The child tried to reach an object bilaterally. It was important that arms must were parallel to ground during reaching (90 degrees of shoulder flexion), clinician measured head extension angle (Figure 3.10.) and trunk flexion angle (Figure 3.11.) at the end of the reaching. The difference between angles of the starting position and the end of reaching was calculated.

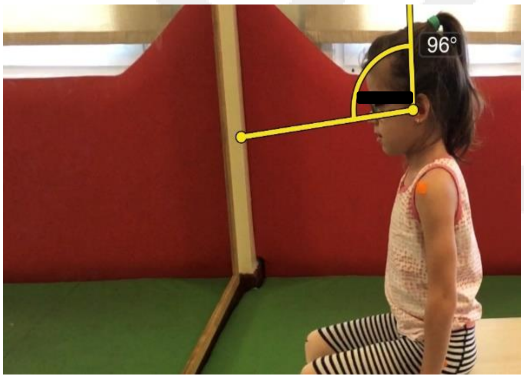

Figure 3.8. Nature head position

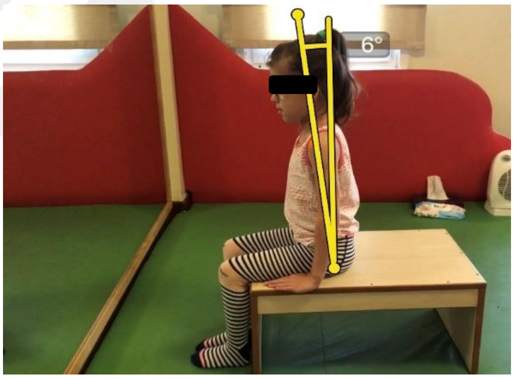

Figure 3.9. Nature trunk position

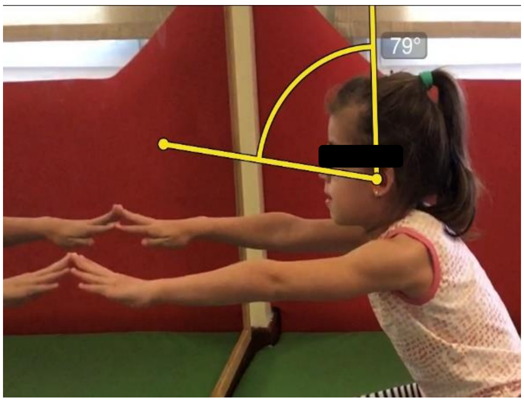

Figure 3.10. The head position at the end of reaching

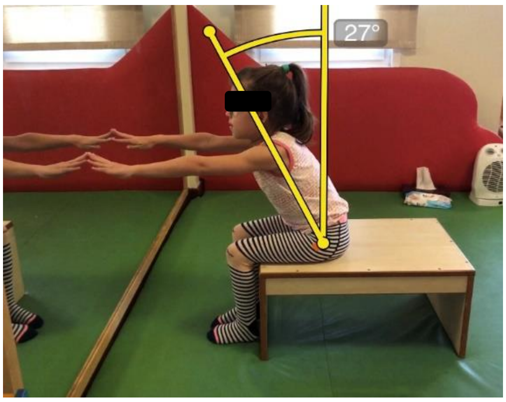

Figure 3.11. The trunk position at the end of reaching

3. 3. Data Analysis

The correlation between head, quality of upper extremities and other parameters (GMFCS and TCMS) were calculated by Statistical Package Analyze for Social Sciences (SPSS) version 22.0 program. Quantitative variables were presented by mean, standard deviation, minimum and maximum values, qualitative variables were presented by frequency and percentage values. Shapiro-Wilks test was used to investigate the normal distribution of variables. As a result of Shaphiro-Wilks; if data found parametric, we used One Way Anova Test with Tukey post hoc test and if datas were nonparametric, we used Kruskal Wallis Test with Mann-Whitney U test. The differences between the groups were evaluted using these test. Additionally, the correlation between the data were calculated by Pearson Correlation Analysis. The level of significance was defined as $p < 0.05$.

4.RESULTS

Our evaluation based on head movement in the sagittal plane and quality of upper extremities in children with spastic CP. The study included 32 children with spastic CP. The demographic features of children (age, weight, body mass index and gender) were presented in Table 4.1. There was no statistical significant difference in demographic features among the children who participated in the study according to Tukey’s HSD post hoc test.

Table 4.1. The demographic characteristics of the children with spastic CP

	All types CP mean±sd	Hemiparetic CP mean±sd	Diparetic CP mean±sd	Tetraparetic CP mean±sd	F	p value
Age (years)	7.09±2.59	6.63±2.61	6.66±2.42	8.22±2.72	2.78	0.249
Weight (kg)	28.18±10.76	27.31±11.54	25.45±9.66	32.88±10.79	2.99	0.224
Height (m)	122±31.25	120±17.42	119.33±13.76	128.66±13.45	2.52	0.283
BMI (kg/m²)	18.08±3.15	18.03±2.94	17.13±2.99	19.40±3.46	2.13	0.344
Male(n)	14(43.8%)	5 (45.5%)	2 (16.7%)	6 (66.7%)	0.50	0.48
Female(n)	18(56.3%)	6 (54.5%)	10 (83.3%)	3 (33.3%)		

BMI: body mass index, CP: cerebral palsy, *p<0.05

The distribution of gross motor functional levels with CP with respect to CP subtypes were given in Table 4.2. There were 11 (34%) hemiparetic CP, 12 (37%) diparetic CP and 9 (28%) tetraparetic CP. When children’s level according to gross motor classification were analyzed; 7 (21.88%) children were at GFMCS I, 15 (46.88%) were at GMFCS II and 10 (31.25%) were at level GMFCS III.

Table 4.2. The distribution of gross motor functional levels over types of CP

	All Types of CP		Hemiparetic CP		Diparetic CP		Tetraparetic CP	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
GMFCS I	7	21.8	5	5.5	4	33.4	0	0
GMFCS II	5	46.8	5	5.5	7	7.3	1	1.1
GMFCS III	0	31.2	1	9.1	1	8.3	8	88.9
n %	32 (100)		11 (34,4)		12 (37,5)		9 (28,1)	

CP: Cerebral Palsy, QUEST T: Quality of Upper Extremity Skills Test, * p<0.05

The comparations of HMSP, QUEST scores, TMSP and TCMS scores according to types of CP were represented (Table 4.3). The sum of scores, the statical difference was found between types of CP and HMSP, QUEST scores, TMSP and TCMS ($p < 0.05$). There were no significant difference between hemiparetic and diparetic groups but, there was a difference between hemiparetic and tetraparetic in terms of HMSP ($p = 0.006$), QUEST Total ($p = 0.001$), TMSP ($p = 0.027$) and TCMS Total ($p = 0.000$)

Table 4.3. Comparations of head movement, QUEST Scores, trunk movement and TCMS score according to types of CP

	Hemiparetic CP mean± sd	Diparetic CP mean± sd	Tetraparetic CP mean± sd	F/H	p
HMSP	15.36±5.12	15.08±4.99	22.00±3.46**	F=6.82 #	0.004*
QUEST	87.54±18.62	89.79±18.20	65.49±12.99**	H=13.14**	0.001*
TMSP	43.18±5.56	40.91±3.31	35.77±3.34**	F=7.80 #	0.002*
TCMS	39.72±6.24	34.08±8.41	18.44±6.04**	F=23.39**	0.000*

CP: Cerebral Palys, MHSP: Movement of head in sagittal plane, MTSP: Movement of trunk in sagital Plane, QUEST: Quality Of Upper Extremity Skills Test, TCMS: Trunk Control Measurement Scale, * p<0.05, ** Tukey pos- hoc p<0.05, # Mann whitney u Test p <0.05

The relationship between head movement in sagittal plane, quality of upper extremities, trunk movement in sagittal plane and trunk control were examined in respect to CP types (Table 4.4). In hemiparetic children, head movement in the sagittal plane correlated with QUEST (Pearson r= -0.72, p < 0.05), MTSP (Pearson r= -0.64, p< 0.05) and TCMS (Pearson r= -0.75, p< 0.05). But, head movement in diparetic CP only showed a correlation with QUEST (Pearson r=-0.91, p< 0.05). The head movement in children with tetraplegic did not show statistical correlation with QUEST, TMSP and TCMS.

Table 4.4. Relationship between head movement, quality of upper extremities, trunk movement and trunk control according to types of CP

		MHSP **r** **p**	**QUEST** **r** **p**	**MTSP** **r** **p**	**TCMS** **r** **p**
Hemiparetic CP	**MHSP**	1	-0,72 **0,012***	-0,64 **0,034***	-0,75 **0,008***
	QUEST		1	0.58 0.059	0.78 **0.004***
	MTSP			1	0.56 0.073
	TCMS				1
Diparetic CP	**MHSP**	1	**-0.91** **0.000***	-0.55 0.062	-0.62 **0.028***
	QUEST	**-0.91** **0.000***	1	0.52 0.100	0.72 **0.012***
	MTSP		0.52 0.100	1	0.46 0.130
	TCMS				1
Tetraparetic CP	**MHSP**	1	-0.59 0.094	-0.51 0.153	-0.30 0.426
	QUEST	-0.59 0.094	1	0.71 **0.032***	0.56 0.112
	MTSP		0.71 **0.032***	1	0.72 **0.026***
	TCMS				1

CP: Cerebral Palys, MHSP: Movement of head in sagittal plane, MTSP: Movement of trunk in sagittal Plane, QUEST: Quality of Upper Extremity Skills Test Total Score, TCMS: Trunk Control Measurement Scale Total Score,* $p<0.05$

The HMSP range, QUEST scores, TMSP range and TCMS score according to type of GMFCS level were showed in Table 4.5. The difference between the HMSP (p = 0.042), QUEST (0.016) and TCMS (0.002) were found statistically difference according to GMFCS levels. However, there was no significant difference between TMSP and GMFCS levels. In Tukey’s HSD post-hoc paired comparisons we concluded that there were no significant differences between GMFCS I and II in terms of HMSP, TMSP and TCMS. But, in terms of CP types, the most obvious statistical difference was found in the tetraparetic CP. Additionally, In Mann Whitney U Test, a significant difference was not found for QUEST between GMFCS I and GMFCS II. Conversely, there was a found significant difference for QUEST between GMFCS II and GMFCS III.

Table 4.5. Comparations of head movement, QUEST Scores, trunk movement and TCMS score according to GMFCS

	GMFCS I mean± sd	**GMFCS II mean± sd**	**GMFCS III mean± sd**	**F/H**	**p**
HMSP	14.71±3.59	15.93±5.50	20.60±5.23**	F=3.539 #	**0.042***
QUEST	89.16±15.97	86.29±21.72	61.79±18.54**	H=8.306**	**0.016***
TMSP	43.00±5.35	61.79±18.54	40.86±5.24	F=3.072	0.062
TCMS	39.42±11.13	34.04±8.19	22.50±9.34**	H=7.912**	**0.002***

GMFCS: Gross Motor Function Classification System, MHSP: Movement of head in sagittal plane, MTSP: Movement of Trunk in Sagittal Plane, QUEST: Quality Of Upper Extremity Skills Test Total Score, TCMS: Trunk Control Measurement Scale Total Score, * p<0.05, ** Tukey pos-hoc p<0.05, # Mann-Whitney U p<0.05

Correlation between GMFCS and head movement, quality of upper extremities, trunk movement in sagittal plane and trunk control were analyzed. The head movement of children who were at GMFCS I, II and III levels correlated with QUEST ($p < 0.05$) and TCMS ($p < 0.05$), and TMSP ($p < 0.05$), but in children at GMFCS, not found statistically correlation between HMSP and TMSP ($p \geq 0.05$) (Table 4.6).

Table 4.6. Relationship between head movement, quality of upper extremities, trunk movement and trunk control according to GMFCS

		MHSP **r** **p**	**QUESt** **r** **p**	**MTSP** **r** **p**	**TCMS** **r** **p**
GMFCS I	**MHSP**	1	-0.90 **0.005***	-0.32 0.487	**-0.94** **0.001***
	QUEST	-0.90 **0.005***	1	0.45 0.311	**0.92** **0.002***
	MTSP		0.45 0.311	1	0.38 0.396
	TCMS				1
GMFCS II	**MHSP**	1	**-0.85** **0.001***	**-0.64** **0.009***	**-0.54** **0.034***
	QUEST	**-0.85** **0.001**	1	0.65 0.011	**0.71** **0.004***
	MTSP		0.65 0.011	1	**0.76** **0.001***
	TCMS				1
GMFCS III	**MHSP**	1	**-0.79** **0.002***	**-0.91** **0.000***	**-0.70** **0.022***
	QUEST	**-0.79** **0.002**	1	**0.90** **0.000***	**0.77** **0.008***
	MTSP		**0.90** **0.000***	1	**0.82** **0.003***
	TCMS				1

GMFCS: Gross Motor Function Classification System, MHSP: Movement of head in sagital plane, MTSP: Movement of Trunk in Sagital Plane, QUEST Total: Quality of Upper Extremity Skills Test Total Score, TCMS Total: Trunk Control Measurement scale Total Score, * $p<0.05$

Comparing the CP types for upper extremities functions, values of QUEST showed that there was a differences between each types of CP (p <0.05). In our study, there were no significant difference between hemiparetic and diparetic CP but, the most pronounced difference seen in tetraparetic CP when we compared to diparetic and hemiparetic CP separately. However, a statistical difference was not found among the CP types in terms of dissociated movements and grasp (Table 4.7).

Table 4.7. Intergroup comparations of subscale of QUEST according to CP types

	Hemiparezis mean± sd	**Diparetic CP mean± sd**	**Tetraparetic Cp mean± sd**	**F/H**	**p**
Dissociated Movements	88.43±14.72	89.99±12.24	76.80±14.57	F=1.00	0.604
Grasp	88.43±14.72	89.99±12.24	75.14±21.92	F=2.32	0.115
Weight Bearing	87.78±64.59	90.89±47.60	75.14±21.92	H=12.30**	**0.002***
Protective Extension	84.28±22.21	85.81±7.11	54.16±25.19	F=7.02#	**0.003***
QUEST	86.34±18.07	88.92±19.95	69.33±19.27	H=13.05**	**0.001***

QUEST : Quality of Upper Extremity Skills Test Total Score, CP: Cerebral Palsy,* p<0.05 ** Tukeypos- hoc. p<0.05, # Mann-Whitney U p<0.05

The children participating in our study were analyzed whether there was a correlation between the subscale of QUEST and HMSP with respect to CP types (Table 4.8). When the results were analyzed on head movement as associated with to grasp (Pearson r= -0.66, r < 0.05), weight bearing (Pearson r= 0.42, p < 0.05), protective extension (Pearson r=0.63, r< 0.05) and QUEST Total (Pearson r=-0.82, r<0.05), there was a correlation between subscale of QUEST and HMSP in all children with CP. However,in this study dissociated movements that is one of the subscales of QUEST were not significantly correlated with head movement in all children with CP.

Table 4.8. Relationship between head movement in sagital plane and quality of upper extremities according to CP types

		Dissociated Movements r p	Grasp r p	Weight Bearing r p	Protective Extension r p	QUEST r p
Hemiparetic CP	**HMSP**	-0.50 0.117	-0.64 **0.031***	0.05 0.865	-0.44 0.172	-0.72 **0.012***
Diparetic CP	**HMSP**	-0.21 0.523	-0.70 **0.015***	-0.71 **0.013***	-0.77 **0.005***	-0.91 **0.000***
Tetraparetic CP	**HMSP**	-0.15 0.691	-1.39 0.721	0.80 0.839	0.06 0.865	-0.59 0.094
All Types	**HMSP**	-0,30 0,092	-0,66 **0,001***	0,42 **0,018**	0,63 **0,003***	-0,82 **0,000***

CP: Cerebral Palsy, QUEST T: Quality of Upper Extremity Skills Test, * p<0.05

As a result of the Kruskal Wallis, trunk control demonstrated a statistically difference for intergroup of the CP types between subscales of TCMS ($p<0.005$) (Table 4.10). The analysis of Mann Whitney U test showed that there were no significant difference between hemiparetic CP and diparetic CP in terms of static dynamic and reaching balance. Whereas, there was a significant difference between hemiparetic-tetraparetic CP and diparetic- tetraparetic CP in terms of static dynamic and reaching balance.

Table 4.9. Intergroup comparations of subscale of TCMS according to CP types

	Hemiparetic CP mean± sd	Diparetic CP mean± sd	Tetraparetic CP mean± sd	H	p
Static Sitting Balance	16.54±2.38	14.41±2.93	8.22±2.81**	24.42	**0.000****
Dynamic Sitting Balance	13.54±4.18	10.25±5.56	3.66±2.23**	12.80	**0.000****
Reaching Balance	9.63±1.28	9.33±1.49	6.55±2.00**	11.01	**0.002****
TCMS	39.72±6.24	34.08±8.41	18.44±6.04**	23.39	**0.000****

CP: Cerebral palsy, DSB: Dynamic Sitting Balance, RB: Reaching Balance SSB: Static Sitting Balance, TCMS T: Trunk Control Measurement scale Total Score *p<0.05, ** Tukey pos-hoc. p<0.05

The children participating in our study were evaluated whether there was a correlation between head movement and trunk control (Table 4.10). It is clearly found that there was a significant negative correlation between head movement and trunk control (TCMS Total) in hemiparetic (Pearson r= -0.75, p =0.008) and diparetic CP (Pearson r=-0.62, p=0.028).

Table 4.10. Relationship between head movement in sagital plane and trunk control according to CP types

		Static sitting balance r p	Dynamic sitting balance r p	Reaching balance r p	TCMS Total r p
Hemiparetic CP	**HMSP**	-0.38 0.240	-0.69 **0.017***	-0.66 **0.027***	-0.75 **0.008**
Diparetic CP	**HMSP**	-0.50 0.095	-0.62 **0.030***	-0.16 0.615	-0.62 **0.028***
Tetraparetic CP	**HMSP**	0.06 0.870	-0.38 0.303	-0.57 0.105	-0.304 0.426
All types	**HMSP**	-0.59 **0.000***	**-0.72** **0.000***	**-0.62** **0.000**	**-0.73** **0.000***

CP: Cerebral Palsy HMSP: Movement of head in sagital plane, QUEST: Quality of Upper Extremity Skills Test, *p<0.05

5. DISCUSSION

The aim of our study was to investigate the relationship between head movements in the sagittal plane and upper extremity skills. The demographic features were evaluated according to types of CP and, there are no significant difference between the demographic features and CP types.

Additionally, subdivision of GMFCS was used to classify children’s motor function levels. According to ICF (International Classification of Functioning, Disability and Health) components (functionality, participation and activity), there was a strong correlation between ICF components, GMFCS and upper extremity abilities in children with CP (80).

In present study, we have found a negative relationship between head movement and upper extremities in both gross motor function and CP types of children.

5.1. Comparations of head movement, upper extremity functions, trunk movement and trunk control according to types of CP

The children with spastic CP participated in this study. The previous studies already showed that spastic type of CP is widespread. In our study, children were classified accordingly in terms of types of spastic CP: 34% were hemiparetic, 38% were diparetic and 28% were tetraparetic CP.

According to types of CP, there is a significant difference between head movement, upper extremity functions, trunk control and trunk movement. Therefore, each type of CP were evaluated separately in terms of head movement, the upper extremity functions, trunk movement and trunk control.

5.1.1. Comparations of head movement and upper extremity functions

In the literature, we did not find the study examining the relationship between head movement and upper extremity functions. Generally, the movements of the head have been examined during gait. Previous research has shown that spastic diparetic children at GMFCS II had increased flexion/extension head range of motion than both of children at GMFCS I and typically developed children (10). In our study, we found that as children at GMFCS II had more head extension compared to GMFCS I, the quality of upper extremity functions have been observed to be decreased.

The results of our study showed that a negative relationship between head movement and upper extremity functions were found in hemiparetic and diparetic children whereas, no significant relationship was found in tetraparetic children. This result showed that as the head extension decreased, the quality of upper extremity functions were increased.

When we compared children at GMFCS I, GMFCS II and GMFCS III in terms of head movement, trunk control, trunk movement and upper extremities functions, there was a remarkable difference at GMFCS I and GMFCS II. But there was no significant difference at GMFCS III in terms of trunk movement. Also, there was a negative correlation between head movement and upper extremity function in any GMFCS levels. We did not find to statically important relationship between head movement and upper extremity function in tetraparetic CP whereas, we found negative relationship in GMFCS III. This may be explain because of tetraparetic children did not take some evaluation position which is essential for QUEST.

In our study, when we compared to dissociated movements, grasp, weight bearing and protective extension which are the subscales of QUEST, there was a significant difference in weight bearing and protective reactions according to CP types. But, dissociated movements and grasp did not statically differ between groups because of the children with tetraparetic CP. The reason for no difference between groups may be the insufficient extension of wrist and elbow and supination. Additionally, children participated in our study had difficulties in wrist stabilization and adjustment for the coordination between arm, hand and fingers.

Park et al. noted that 234 children with CP had flexor position in wrist, fingers and thumb in palm deformity and insufficient pronation, forearm supination and elbow extension. Park's study shown that abnormal position and insufficient range of motion in upper extremities had an affect on the hand functions (81).

In the previous studies, the movements of the head have been examined during gait. Heyrman et al. compared the movement of the head between children with diparetic CP and healthy peers. They reported that children with diparetic CP had increased head range of motion in all planes. The study's result indicated that dynamic stabilization was not sufficient during gait due to increased ROM of head (82).

Additionally, Tokizane et al. found that head and neck positioning was important on motor unit activity during upper extremities functions in both healthy and neurological neurologically impaired children. Because the tonic neck reflex, asymmetrical tonic neck reflex and an asymmetrical tonic neck reflex affects upper extremities functions due to abnormal head positions. (83). However, we did not evaluate and observe these abnormal reflexes in children who participated to our study.

In our study, there was only a negative correlation between head movement and grasp in hemiparetic CP. In diparetic CP, we found a significant negative relationship between grasp, weight bearing and protective reactions according to head movements.

5.1.2. Relationship of trunk control between upper extremity functions and head movement

The trunk control of children with CP is variable according to the topographic distribution of CP. Heyrman et al. evaluated the trunk control relativity to the topographic disturbance. The mean score of TCMS was 44.5 for hemiparetic CP, 40 for diparetic and 13.5 for tetraparetic CP. Additionally, when TCMS was evaluated in terms of subscales, it is observed that although children with hemiparetic and diparetic CP did not have much difficulty in static sitting balance, they had difficulties in dynamic balance. The children with tetraparetic CP had difficulties in both static and dynamic balance (82). In our study, we also found the same results as the study of Heyrman et al. The most affected trunk control was observed in tetraparetic CP whereas, there was no significant difference between hemiparetic and diparetic CP.

Previous research found that underdeveloped or insufficient trunk control caused an unstable head due to the lack of head control. Saavedra et al. compared to the head movement's and trunk control in terms of amplitude and velocity of a head movement in sitting position during reaching. They found that head control varies depending on the trunk control. When children's trunk control is increased, amplitude and velocity of head movement decreased (67). Our data also revealed that there was a significant negative relationship between trunk control and head movement.

Yildiz et al. found that trunk control correlated with upper extremity functions and head stability. In that study, the trunk control was increased by the addition of external support (chair support) to compare trunk control in terms of additional external supports. The children who had poor trunk control had difficulties in performing isolated movements and upper extremities functions and decreased head stability. Therefore, abnormal movement of trunk compensates insufficient upper extremity functions (84).

Our results showed that trunk control was correlated with trunk movement in the sagittal plane in children with tetraparetic CP but, not statically correlated with hemiparetic and diparetic CP. We observed in tetraparetic CP, increased in insufficient pelvis stabilization and trunk control leads to an increased kyphosis or lordosis and upper extremities fixation may limit upper extremity functions. Therefore, children with tetraparetic CP would difficulty in trunk flexion during reaching. Additionally, although children with hemiparetic CP had better gross motor functions than any other type of CP, we noticed an abnormal patters in upper extremities during activities. Previous studies have also revealed that increased trunk flexion as a compensatory mechanism was also seen during grasp and reaching activities in hemiparetic CP (85).

We found a positive relationship between trunk control and upper extremity functions in children hemiparetic and diparetic CP. But, in the children with tetraparetic CP, there was no statically important relationship between trunk control and upper extremity functions. May the reason is that tetraparetic children did not take some evaluation positions of QUEST. Considering the aforementioned, we found that as the trunk control of is increased, extension of the head was decreased and the upper extremities quality was increased.

Dynamic sitting balance is important in reaching activities. Brundavanam et al. found that the increase in dynamic sitting balance also increased upper extremity functions due to the development of proximal stabilization in upper extremities (86). In our study, we evaluated head movement during anterior reaching. Therefore, in our comparison of the outcomes of dynamic sitting and reaching balance from the viewpoint of head movement, we found a negative correlation in hemiparetic CP; only negative correlation was found between dynamic sitting balance in diparetic CP.

It is clearly found that children with CP experienced more difficulties than normally developing children in upper extremity functions (67). The trunk control and head movement play a role in upper extremity activities. Therefore, in order to reduce the limitation of children with CP in upper extremities, increasing trunk control and head control should be achieved with treatments.

Our study has several limitations:

- Our clinic status was not able to evaluate the head movement during each part of the upper extremity functions. Therefore, we measured the head of motion in anterior reaching.

- Abnormal posture can affect the trunk control. However, in this study, we did not assess all the body posture. For this purpose, the section in the QUEST that evaluates the upper part of body, it is not sufficient.
- The children with CP are not classified according to manual abilities and nor per their muscle tonus.

As a result of our study, whereas more studies are needed to investigating the relationship between head movement in the sagittal plane and upper extremities functions in children with spastic CP. In our study we found that;

- as the head extension decreased, quality of upper extremity functions were increased
- if the children with CP had better trunk control, extension of the head was decreased during anterior reaching.

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APPENDIX

APPENDIX 1. Ribem Approval Form

Ribem
RİSKLİ BEBEK DANIŞMA MERKEZİ

22 Aralık 2018

YEDİTEPE ÜNİVERSİTESİ REKTÖRLÜĞÜ'NE

(SAĞLIK BİLİMLERİ ENSTİTÜ MÜDÜRLÜĞÜ)

Enstitünüzün Fizyoterapi ve Rehabilitasyon Yüksek Lisans Programı öğrencisi Ezgi Koyuncu'nun "Serebral Palsili Çocuklarda Sagital Düzlemde Baş Hareketi İle Üst Ekstiremite Fonksiyonları Arasındaki İlişki" isimli yüksek lisans tez çalışması kapsamındaki araştırmalarını 01.02.2019 – 30.06.2019 tarihleri arasında merkezimizde yapması uygun bulunmuştur.

Bilgilerinize arz ederim.

Saygılarımla

Uzm. Fzt. Feride Bilir

Göztepe Mah. Göksu Evleri Sitesi, Oya Çiçeği Sok. No: 35 (B142a) Anadoluhisarı Beykoz İstanbul
Tel: 0216 668 04 05 (Pbx) – 0530 695 04 04 Fax: 0216 465 20 01 e-mail: info@ribem.com.tr
www.ribem.com.tr

APPENDIX 2. Ethical Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1623 **28/02/2019**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Ezgi Koyuncu)

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü Prof. Dr. Feryal Subaşı'nın sorumlu olduğu **"Serebral Palsili Çocuklarda Sagital Düzlemde Baş Hareketi ile Üst Ekstremite Fonksiyonları Arasındaki İlişki"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası (**1593** kayıt Numaralı KAEK Başvuru Dosyası), Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **27.02.2019** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 975**).

Ancak uygunluk kararı, "İlaç ve Biyolojik Ürünlerin Klinik Araştırmaları hakkında yönetmeliği" gereği, söz konusu araştırmanın, Türkiye İlaç ve Tıbbi Cihaz Kurumu'na sunulması ve onaylanmasını takiben geçerli olacaktır. İlgili kuruma, araştırma dosyanızı bir üst yazı ile sunmanız ve takip etmeniz gerekmektedir.

Bilginizi ve gereğini arz / rica ederim.

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
T. 0216 578 00 00 www.yeditepe.edu.tr F. 0216 578 02 99

APPENDIX 3. Informed Written Consent

Araştırmanın Adı: Serebral Palsili Çocuklarda Başın Sagital Düzlemde Hareketi İle Üst Ekstiremite Fonksiyonları Arasındaki İlişki

"Sayın gönüllü ebeveyn,

Yeditepe Üniversitesi Sağlık Bilimler Enstitüsü Fizyoterapi ve Rehabilitasyon Yüksek Lisans Tezi kapsamında planlanmış olan yukarıda adı yazılı araştırmaya katılmak üzere davet edilmiş bulunuyorsunuz. Bu araştırmada yer almayı kabul etmeden önce, araştırmanın ne amaçla yapılmak istendiğini anlamanız ve kararınızı bu bilgilendirme çerçevesinde özgürce vermeniz gerekmektedir. Aşağıdaki bilgileri lütfen dikkatlice okuyunuz, sorularınız olursa sorunuz ve açıkça yanıtlar isteyiniz."

Çalışma kapsamında, çocuğunuz hakkındaki bilgi siz ebeveynlerine sorularak elde edilecektir. Bu sorular, çocuğunuzun fiziksel durumu, şuan ki sağlık durumu ve siz ebeveynlerden elde edebileceğimiz bilgilerden oluşacaktır. Ayrıca çocuğunuz fizyoterapist tarafından uygulanacak bir dizi değerlendirmeye tabi tutulacaktır. Bu değerlendirmede; çocuğunuzun, her bir kas grubuna ait sertlik ve derecesi, baş hareketliliği, gövde kontrolü, nesne tutma ve ellerini kullanma becerileri, el, dirsek ve omuz fonksiyonlarının kapasitesini ölçecek testler yer alacaktır.

Bu araştırmada yer almak tümüyle sizin isteğinize bağlıdır. Araştırmada yer almayı reddedebilirsiniz ya da başladıktan sonra yarıda bırakabilirsiniz. Bu araştırmanın sonuçları bilimsel amaçlarla kullanılacaktır. Araştırmadan çekilmeniz ya da araştırmacı tarafından araştırmadan çıkarılmanız halinde, sizle ilgili veriler kullanılmayacaktır. Ancak veriler bir kez anonimleştikten sonra araştırmadan çekilmeniz mümkün olmayacaktır. Sizden elde edilen tüm bilgiler gizli tutulacak, araştırma yayınlandığında da varsa kimlik bilgilerinizin gizliliği korunacaktır.

"Yukarıda yer alan ve araştırmaya başlanmadan önce gönüllülere verilmesi gereken bilgileri içeren metni okudum (ya da sözlü olarak dinledim). Eksik kaldığını düşündüğüm konularda sorularımı araştırmacılara sordum ve doyurucu yanıtlar aldım. Yazılı ve sözlü olarak tarafıma sunulan tüm açıklamaları ayrıntılarıyla anladığım kanısındayım. Çalışmaya katılmayı isteyip istemediğim konusunda karar vermem için yeterince zaman tanındı. Bu koşullar altında, araştırma kapsamında elde edilen şahsıma ait bilgilerin bilimsel amaçlarla kullanılmasını, gizlilik kurallarına uyulmak kaydıyla sunulmasını ve yayınlanmasını, hiçbir baskı ve zorlama altında kalmaksızın, kendi özgür irademle kabul ettiğimi beyan ederim."

Gönüllü Ebeveynin Adı Soyadı : Araştırmacının Adı Soyadı:

İmza/ Tarih: **İmza/ Tarih:**

APPENDIX 4: Demographic Form

YEDİTEPE ÜNİVERSİTESİ
SAĞLIK BİLİMLERİ ENSTİTÜSÜ
FİZİK TEDAVİ VE REHABİLİTASYON BÖLÜMÜ

Genel Bilgi Değerlendirme Formu

Tarih :…/….. /………

1)Adı Soyadı:

2)Doğum Tarihi:

3) Cinsiyet: ( ) Kız ( ) Erkek

4) Doğum Anındaki Boy Uzunluğu (cm):

5) Doğum Anındaki Vücut Ağırlığı (kg) :

6)Şuan ki Boy Uzunluğu (cm):

7)Şuan ki Vücut Ağırlığı (kg):

8) Vücut Kitle İndeksi:

9) Dominant Taraf: El ( ) sağ ( ) sol

Ayak ( ) sağ ( ) sol

10)Çocuğunuzun herhangi bir sürekli hastalığı var mı? Varsa hangileri?

( ) Sürekli bir hastalığı yok ( ) Ortopedik hastalık ( ) Nörolojik hastalık

( ) Metabolizmal hastalık ( ) Göğüs hastalıkları ( ) Görme sorunları

( )İşitme sorunları

11)Çocuğunuz herhangi bir ameliyat geçirdi mi? ( ) Evet........... Belirtiniz ( ) Hayır

12)çocuğunuz herhangi bir ameliyat geçirdi ise ne zaman olduğunu belirtiniz.

( ) 1-3 yıl önce ( ) 3-5 yıl önce ( ) 5- ve daha öncesi

13)Çocuğunuz botulinum toksin uygulması geçirdi mi? Geçirdiyse ne zaman?

( ) Hayır geçirmedi.
( )6- 12 ay önce ( )1-3 yıl önce ( )3-5 yıl önce ( )5-7 yıl önce

14) Çocuğunuz düzenli olarak fizyoterapi desteği alıyor mu? ( ) Evet ( ) Hayır

15)Çocuğunuz düzenli fizyoterapi desteği alıyor ise ne zamandır almaktadır?

( )6- 12 aydır ( )1-3 yıldır ( )3- 5 yıldır ( ) 5 ve daha fazlası

16)çocuğunuz düzenli fizyotarapi desteğini ne sıklıkta almaktadır?

( )Haftada 1 kez ( )Haftada 2-3kez

( )Haftada 4-5 kez ( )Ayda 2 -5 kez

17)Alınan fizyoterapi desteği her seferinde kaç dakika sürüyor?

( )20-30 dk ( )30 – 60 dk ( )60 dk. dan fazla

APPENDIX 5: Trunk Control Measurement Scale (TCMS)

Trunk Control Measurement Scale (TCMS)

Test instructions

Orthoses, shoes and/or a trunk brace should be taken off.
The starting position is the same for each item. The patient is sitting on the edge of a treatment table without back, arm or feet support. The thighs make full contact with the table.
The hands rest on the legs, close to the body. The patient is asked to sit upright at the start of each item and needs to be encouraged to maintain the upright position during the performance of the task. The term 'upright' refers to the most upright sitting position that the child can assume. This position can differ from child to child. This position is the reference position for identification of aberrations in performance and/or compensations.
Each item is performed three times. The best performance is taken into account for scoring.
If the child performs the tasks of subscale 'static sitting balance' with single arm support, only support with the hand flat on the table without grasping is allowed.

Item	**STATIC SITTING BALANCE** Testing procedure: Each item is verbally explained to the patient and demonstrated by the tester if needed		Bilat/ Left	Right
1	Starting position (unsupported sitting, hands on legs) **Patient is instructed to <u>sit upright</u> and <u>hold</u> this position for 10 seconds**	Patient falls or can only maintain upright sitting with double arm support	□ 0	
		Patient can only maintain upright sitting with single arm support for 10 sec	□ 1	
		Patient can maintain upright sitting without arm support for 10 sec	□ 2	
		If score = 0, then total score = 0		
2	Starting position **Patient <u>liftsbotharms</u> at eye height in one second and returns to starting position**	Patient falls or can not lift arms	□ 0	
		Patient can lift arms without falling but with compensations. Possible compensations are: (1) backward lean, (2) increase of trunk flexion, (3) lateral flexion, (4) other	□ 1	
		Patient lifts arms without compensations	□ 2	
3	Starting position **<u>Therapist</u> <u>crosses</u> one leg over the other leg**	Patient falls, can not cross legs or can only maintain sitting with double arm support	□ 0	□ 0
		Patient can maintain sitting with single arm support for 10 sec	□ 1	□ 1
		Patient can maintain sitting without arm support for 10 sec	□ 2	□ 2
4	Starting position **<u>Patient</u> <u>crosses</u> one leg over the other leg (assistance with one hand is allowed)** 'minimal' = small trunk movements without signs of imbalance of trunk during movement of leg 'clear' = clear signs of imbalance i.e. lateral flexion or flexion of trunk	Patient falls, can not cross legs or can only cross legs with double arm support	□ 0	□ 0
		Patient can only cross legs with single arm support	□ 1	□ 1
		Patient crosses legs without arm support but with clear trunk displacement	□ 2	□ 2
		Patient crosses legs with minimal trunk displacement	□ 3	□ 3

5	Starting position **Patient <u>abducts</u> one leg over 10 cm and returns to starting position** (10 cm width=width of the knee) 'minimal' = small trunk movements without signs of imbalance of trunk during movement of leg 'clear' = clear signs of imbalance i.e. lateral flexion or flexion of trunk	Patient falls, can not abduct leg or can only abduct leg with double arm support	□ 0	□ 0
		Patient can only abduct leg with single arm support	□ 1	□ 1
		Patient abducts leg without arm support but with clear trunk displacement	□ 2	□ 2
		Patient abducts leg with minimal trunk displacement	□ 3	□ 3
		Total static sitting balance		**/20**

DYNAMIC SITTING BALANCE

Selective movement control

Testing procedure: First, each item is verbally explained and demonstrated by the tester. Secondly, the item is demonstrated on the patient with manual guidance. Thirdly, the patient is asked to perform the expected movement under manual guidance of the tester. Then, the patient performs the item on its own in three attempts.

			Bilat/ Left	Right
6a	Starting position - arms crossed over chest **Patient is instructed to <u>lean forward</u> with a fixed trunk for approximately 45° and return to starting position** normal righting reaction of the head i.e. limited head extension is not scored as a compensation	Patient falls or can not reach target position	□ 0	
		Patient can lean forward	□ 1	
		If score = 0, then item 6b = 0		
6b		Patient compensates (1) increased head extension, (2) increased trunk flexion, (3) increased lumbar lordosis, (4) increased knee flexion, (5) other	□ 0	
		Patient leans forward without compensations	□ 1	
7a	Starting position - arms crossed over chest **Patient is instructed to <u>lean backward</u> with a fixed trunk for approximately 45° and return to starting position** normal righting reaction of the head i.e. limited head flexion is not scored as a compensation	Patient falls or can not reach target position	□ 0	
		Patient can lean backward	□ 1	
		If score = 0, then item 7b = 0		
7b		Patient compensates (1) increased head flexion, (2) increased trunk flexion, (3) increased knee extension, (4) other	□ 0	
		Patient leans backward without compensations	□ 1	
8a	Starting position **Patient is instructed to touch the table with the <u>elbow</u> at level of the femoral head (by shortening the ipsilateral side and lengthening the contralateral side) and return**	Patient falls or does not touch the table with the elbow	□ 0	□ 0

	to starting position	Patient can touch the table with the elbow *If score = 0, then item 8b and 8c = 0*	□ 1	□ 1
8b		Patient demonstrates (1) no shortening/lengthening or (2) opposite shortening/lengthening	□ 0	□ 0
		Patient demonstrates expected shortening/lengthening *If score = 0, then item 8c = 0*	□ 1	□ 1
8c		Patient compensates: (1) increased trunk flexion, (2) forward or backward lean, (3) pelvic lift, (4) other	□ 0	□ 0
		Patient touches the table without compensations	□ 1	□ 1
9a	Starting position **Patient is instructed to <u>liftthe pelvis</u> at one side and return to starting position.** No lifting of the thigh is allowed.	Patient falls or can not lift the pelvis	□ 0	□ 0
		Patient can lift the pelvis *If score = 0, then item 9b and 9c = 0*	□ 1	□ 1
9b		Patient demonstrates no shortening/lengthening	□ 0	□ 0
		Patient demonstrates partially expected shortening/lengthening (partial = short and/or small ROM)	□ 1	□ 1
		Patient demonstrates expected shortening/lengthening *If score = 0, then item 9c = 0*	□ 2	□ 2
9c		Patient compensates: (1) contralateral head flexion, (2) marked lateral trunk displacement, (3) other	□ 0	□ 0
		Patient lifts the pelvis without compensations	□ 1	□ 1
10a	Starting position - arms crossed over chest **Patient is instructed to <u>rotate theuppertrunk</u> three times with head fixated in starting position.** The movement is initiated from the shoulder girdle.	Patient (1) falls, (2) can not rotate the upper trunk i.e. patient can not perform the rotation movement, even not with the entire trunk, or (3) demonstrates no selective rotation of the upper trunk (en bloc)	□ 0	
		Patient demonstrates partial selective rotation of the upper trunk (partial = asymmetrical, small ROM, more shoulders than trunk)	□ 1	
		Patient demonstrates expected selective rotation of the upper trunk *If score = 0, then item 10b = 0*	□ 2	
10b		Patient rotates the upper trunk with head rotation	□ 0	
		Patient rotates the upper trunk without head rotation	□ 1	
11a	Starting position - arms crossed over chest **Patient is instructed to <u>rotate thelowertrunk</u> three times with head fixated in starting position.** The movement is initiated from the pelvic girdle.	Patient (1) falls, (2) can not rotate the lower trunk i.e. patient can not perform the rotation movement, even not with the entire trunk, or (3) demonstrates no selective rotation of the lower trunk (en bloc)	□ 0	
		Patient demonstrates partial selective rotation of the lower trunk (partial = asymmetrical, small ROM, additional movement of upper trunk)	□ 1	
		Patient demonstrates expected selective rotation of the lower trunk	□ 2	

		If score = 0, then item 11b = 0		
11b		Patient compensates with pelvic tilt	□ 0	
		Patient rotates the lower trunk without compensations	□ 1	
12a	Starting position - arms crossed over chest **Patient is instructed to <u>shuffle</u> <u>thepelvisthreetimes</u> in a <u>forward</u> direction and return <u>backwards</u> in three times to the starting position** shuffle movement=combination of lateral flexion and rotation with the pelvis, alternated left and right	Patient falls or can not shuffle the pelvis in forward and backward direction i.e. no displacement of the body in either direction	□ 0	
		Patient can partially shuffle the pelvis (partial = with mainly lateral flexion and little rotation; small ROM; takes a lot of effort)	□ 1	
		Patient can shuffle the pelvis by use of both lateral flexion and rotation in one direction and partially in the other direction	□ 2	
		Patient can shuffle the pelvis by use of both lateral flexion and rotation in both directions	□ 3	
		If score = 0, then item 12b = 0		
12b		Patient compensates with excessive trunk displacement	□ 0	
		Patient shuffles pelvis without compensations	□ 1	
		Total selective movement control		**/28**
	Dynamic reaching (equilibrium reactions) Testing procedure: Each item is verbally explained by the tester and then performed three times by the patient.		Bilat/ Left	Right
13	Starting position - arms straight forward **Patient is instructed to <u>reach forward</u> with <u>botharms straight</u> to target at eye level positioned at a distance, corresponding with the forearm length and return to starting position**	Patient falls or can not reach target	□ 0	
		Patient reaches target, but has difficulties in performance. Difficulties are: (1) takes a lot of effort i.e. slow and with difficulty or (2) uses some support of hand when approaching the starting position	□ 1	
		Patient reaches target and returns to starting position without difficulties	□ 2	
14	Starting position - one arm straight sideward and other hand on leg **Patient is instructed to <u>reach sideward</u> with one arm straight to target at eye level positioned at a distance, corresponding with the forearm length and return to starting position**	Patient falls or can not reach target	□ 0	□ 0
		Patient reaches target, but has difficulties in performance. Difficulties are: (1) takes a lot of effort i.e. slow and with difficulty or (2) uses some support of hand when approaching the starting position	□ 1	□ 1
		Patient reaches target and returns to starting position without difficulties	□ 2	□ 2

15	Starting position - one arm straight sideward and other hand on leg **Patient is instructed to <u>reach acrossthemidline</u> with one arm (reach to the opposite side) and return to starting position.** The target is positioned at eye level at a distance corresponding with half the forearm length of the reaching arm.	Patient falls or can not reach target	□ 0	□ 0
		Patient reaches target, but has difficulty in performance. Difficulties are: (1) takes a lot of effort i.e. slow and with difficulty or (2) uses some support of hand when approaching the starting position	□ 1	□ 1
		Patient reaches target and returns to starting position without difficulties	□ 2	□ 2
		Total dynamic reaching		**/10**
		TOTAL TCMS score /58		

Reference:

Heyrman L, Molenaers G, Desloovere K, Verheyden G, De Cat J, Monbaliu E, Feys H. A clinical tool to measure trunk control in children with cerebral palsy: the Trunk Control Measurement Scale. Research in Developmental Disabilities 2011; 32(6):2624-2635.

APPENDIX 6. Quality Of Upper Extremity Skills Test (QUEST)

QUEST©

Quality of Upper Extremity Skills Test

Carol DeMatteo, Mary Law, Dianne Russell, Nancy Pollock, Peter Rosenbaum, Stephen Walter

Child's Name: ______________________ Date: ______________ (year/month/day) Time of Day: __________

Evaluator: ______________________ Age: __________ years __________ months

Testing Conditions:

Room ______________________

Seating (e.g., insert) ______________________

Table (e.g., cutout) ______________________

Orthotics (e.g., splints/AFOs) ______________________

Others Present (e.g., parent) ______________________

Score Key

✔ = Yes (able to complete item according to specification)

✘ = No (can not <u>or</u> will not complete item)

NT = Not Tested (not able to administer item)

*If a complete section is not tested, insert **NT** in summary score*

MAKE SURE THERE IS A SCORE ENTERED IN EVERY SCORING BOX

SUMMARY SCORE (transfer from QUEST Scoring Sheet)

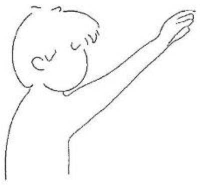
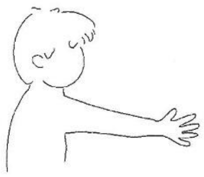
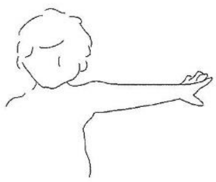
A:	DISSOCIATED MOVEMENTS	
B:	GRASPS	
C:	WEIGHT BEARING	
D:	PROTECTIVE EXTENSION	

TOTAL SCORE = SUM OF SCORES FOR EACH SECTION TESTED / TOTAL # OF SECTIONS TESTED

= ______________________

A. DISSOCIATED MOVEMENTS
Shoulder Items

Start Position: sitting in chair | no table | hands on lap

ITEM "SHOULDER"	SCORE L <90	SCORE L ≥90	SCORE R <90	SCORE R ≥90	CRITERIA
1. Flexion 	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
2. Flexion with Fingers Extended 	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
3. Abduction 	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
4. Abduction with Fingers Extended 	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension

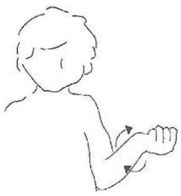
✔ ☐ ✘ ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Elbow Items

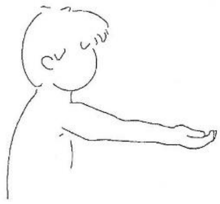
Start Position: sitting in chair — no table — hands on lap

ITEM "ELBOW"	SCORE L half <range	SCORE L half ≥range	SCORE R half <range	SCORE R half ≥range	CRITERIA
1. Flexion	☐	☐	☐	☐	forearm: complete supination
2. Extension	☐	☐	☐	☐	forearm: complete supination
3. Flexion	☐	☐	☐	☐	forearm: complete pronation
4. Extension	☐	☐	☐	☐	forearm: complete pronation

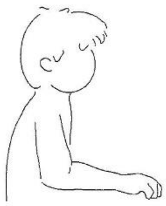
1. Flexion



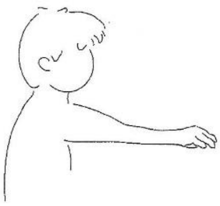
2. Extension



3. Flexion



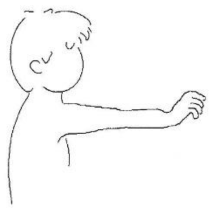
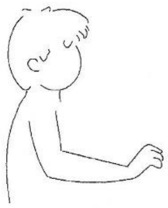
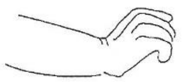
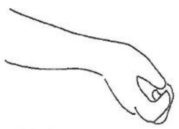
4. Extension



✔ ☐ ✘ ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Wrist Items

Start Position: sitting at table forearms may be on table

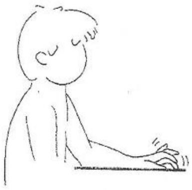
ITEM "WRIST"	SCORE L half <range	L half ≥range	SCORE R half <range	R half ≥range	CRITERIA
1. Extension 	☐	☐	☐	☐	elbow: complete extension* **see manual for definition of complete extension*
2. Extension 	☐	☐	☐	☐	elbow: at least 10° flexion
3. Extension 	☐	☐	☐	☐	forearm: complete pronation
4. Extension 	☐	☐	☐	☐	forearm: complete supination
5. Flexion 	☐	☐	☐	☐	forearm: complete supination

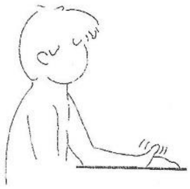
✔ ☐ ✘ ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Finger Items

Start Position: sitting at table forearms must rest on table

ITEM	SCORE L	SCORE R	CRITERIA
1. Independent Finger Wiggling	☐	☐	dissociation of all fingers no associated reactions
2. Independent Thumb Movement	☐	☐	no associated reactions



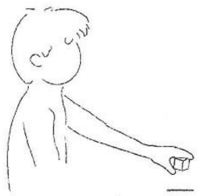


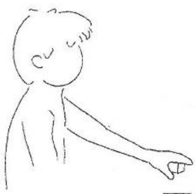
Grasp of 1" Cube

Start Position: sitting at table cube at distance requiring elbow extension

Note: If Item 1 is performed, then Item 2 should also be scored YES

ITEM	SCORE L	SCORE R	CRITERIA
1. Grasp Using Thumb	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension
2. Grasp Using Palm	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension





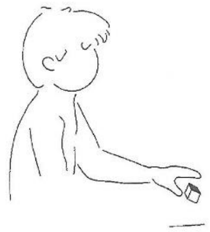
✔ ☐ ✘ ☐ NT ☐

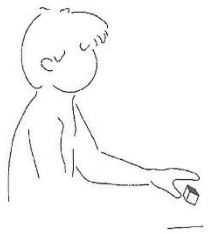
A. DISSOCIATED MOVEMENTS continued
Release of 1" Cube

Start Position: sitting at table — cube in child's hand *

*** Allowable to put cube in child's hand if he/she can't actively grasp**
Note: If Item 1 is performed, then Item 2 should also be scored YES

ITEM	SCORE L	SCORE R	CRITERIA
1. Release from Thumb and Fingers	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension
2. Release from Palm	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension





✔ ☐ ✘ ☐ NT ☐

Scoring for Part A: DISSOCIATED MOVEMENTS *(pages 2-6)*

Total ✔ : ☐ = a

Total ✘ : ☐ = b

Total NT : ☐ = c

TRANSFER TO QUEST SCORING SHEET ON PAGE i

B. GRASPS
Sitting Posture *during grasps*

Note: **Observations for scoring this item should be made while administering the grasp items in the following section.**

ITEM	SCORE: NORMAL	SCORE: ATYPICAL
Head	☐	☐ Left Right Flexion Extension *circle atypical posture*
Trunk	☐	☐ Forward ☐ Lateral *check off position*
Shoulders	☐	☐ Retracted ☐ Elevated *check off position*

Scoring for Part B1: GRASPS - Sitting Posture *(page 7 only)*

Total Normal (max. = 3) : ☐ = d

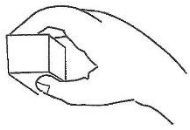
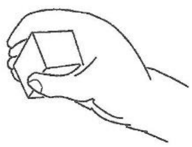
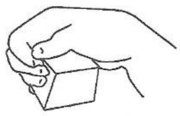
Total Atypical (max. = 5) : ☐ = e

TRANSFER TO QUEST SCORING SHEET ON PAGE ii

B. GRASPS continued
Grasp of 1" Cube

Start Position: sitting at table — cube on table within comfortable reach

Note: Once a grasp has been performed, give a YES score for all those below it. If grasp observed is not listed, then score NO in all boxes and describe it under "Other" below.

ITEM	SCORE L	SCORE R	CRITERIA
1. Radial Digital	☐	☐	wrist: neutral to extension
			
2. Radial Palmar	☐	☐	wrist: neutral to extension
			
3. Palmar	☐	☐	
			

Other:

____

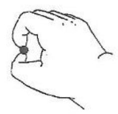
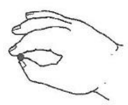
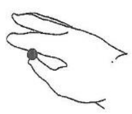
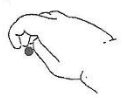
____

✔ ☐ ✘ ☐ NT ☐

B. GRASPS continued
Grasp of Cereal

Start Position: sitting at table

Note: Once a grasp has been performed, give a YES score for all those below it. If grasp observed is not listed, then score NO in all boxes and describe it under "Other" below.

ITEM	SCORE L	SCORE R	CRITERIA
1. Fine Pincer 	☐	☐	wrist: neutral to extension
2. Pincer 	☐	☐	wrist: neutral to extension
3. Inferior Pincer 	☐	☐	
4. Scissor 	☐	☐	
5. Inferior Scissor 	☐	☐	

Other:

____

____

✔ ☐ ✘ ☐ NT ☐

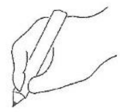
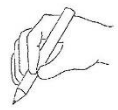
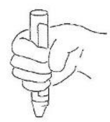
B. GRASPS continued
Grasp of Pencil or Crayon

Start Position: **sitting at table** **pencil placed midline vertical with point facing child**

Note: **Child must pick up pencil on his/her own.**
Once a grasp has been performed, give a YES score for all those below it.

Circle one of: **L** Dominance **R** Dominance **L** Preference **R** Preference

Circle one of: grasp of **Pencil** grasp of **Crayon**

ITEM	SCORE L	SCORE R	
1. Dynamic Tripod (pencil, grasped distally - precise opposition of thumb, index & middle finger)	☐	☐	
2. Static Tripod (pencil grasped proximally - crude approximation of thumb, index & middle finger)	☐	☐	
3. Digital Pronate	☐	☐	
4. Palmar Supinate	☐	☐	

Other: ____________________

✔ ☐ ✘ ☐ NT ☐

Scoring for Part B: GRASPS *(pages 8-10)*

Total ✔ : ☐ = f

Total ✘ : ☐ = g

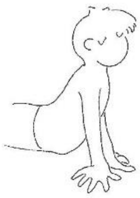
Total NT : ☐ = h

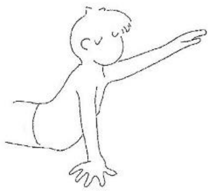
TRANSFER TO QUEST SCORING SHEET ON PAGE **ii**

C. WEIGHT BEARING

Start Position: **prone** *or* **4 point**

Note: Once a position is scored, give a YES score for all those below it

ITEM		SCORE		CRITERIA
Circle test position: prone 4 point				
		L	R	
1. Weight Bearing				
	a) elbow extended, hand open	☐	☐	Thumb must be out of palm for all weight bearing items or they are scored "NO".
	b) elbow extended, fingers flexed	☐	☐	
	c) elbow extended, hand fisted	☐	☐	
	d) elbow flexed, hand open	☐	☐	
	e) elbow flexed, fingers flexed	☐	☐	
	f) elbow flexed, hand fisted	☐	☐	

ITEM		SCORE
2. Weight Bearing with Reach		
	a) Bears weight on **LEFT** hand with **LEFT** elbow completely extended and reaches with other arm.	☐
	b) Bears weight on **RIGHT** hand with **RIGHT** elbow completely extended and reaches with other arm.	☐

✔ ☐ ✘ ☐ NT ☐

C: WEIGHT BEARING continued
Sitting

Start position: sitting on floor preferably cross-legged

ITEM	SCORE L	SCORE R	CRITERIA

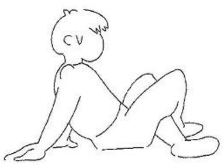
1. **Hands forward** - circle test position: cross-legged ring other ______

Item	L	R	Criteria
a) elbow extended, hand open	☐	☐	Thumb must be out of palm for all items.
b) elbow extended, fingers flexed	☐	☐	
c) elbow extended, hand fisted	☐	☐	
d) elbow flexed, hand open	☐	☐	
e) elbow flexed, fingers flexed	☐	☐	
f) elbow flexed, hand fisted	☐	☐	

2. **Hands by side** - circle test position: cross-legged ring other ______

Item	L	R	Criteria
a) elbow extended, hand open	☐	☐	Thumb must be out of palm for all items.
b) elbow extended, fingers flexed	☐	☐	
c) elbow extended, hand fisted	☐	☐	
d) elbow flexed, hand open	☐	☐	
e) elbow flexed, fingers flexed	☐	☐	
f) elbow flexed, hand fisted	☐	☐	

3. **Hands behind** - circle test position: cross-legged ring other ______



Item	L	R	Criteria
a) elbow extended, hand open	☐	☐	Thumb must be out of palm for all items.
b) elbow extended, fingers flexed	☐	☐	
c) elbow extended, hand fisted	☐	☐	
d) elbow flexed, hand open	☐	☐	
e) elbow flexed, fingers flexed	☐	☐	
f) elbow flexed, hand fisted	☐	☐	

✔ ☐ ✘ ☐ NT ☐

Scoring for Part C: WEIGHT BEARING *(pages 11-12)*

Total ✔ : ☐ = i

Total ✘ : ☐ = j

Total NT : ☐ = k

TRANSFER TO QUEST SCORING SHEET ON PAGE iii

D: PROTECTIVE EXTENSION

Start position: **preferably ring sitting** *or* **kneeling**

Note: Once a position is scored, give a YES score for all those below it.

ITEM	SCORE L	SCORE R
1. **Protective Extension - Forward** - circle start position: ring sit kneeling other ______		
a) elbow extended, hand open	☐	☐
b) elbow extended, fingers flexed	☐	☐
c) elbow extended, hand fisted	☐	☐
d) elbow flexed, hand open	☐	☐
e) elbow flexed, fingers flexed	☐	☐
f) elbow flexed, hand fisted	☐	☐
2. **Protective Extension - Side** - circle start position: ring sit kneeling other ______		
a) elbow extended, hand open	☐	☐
b) elbow extended, fingers flexed	☐	☐
c) elbow extended, hand fisted	☐	☐
d) elbow flexed, hand open	☐	☐
e) elbow flexed, fingers flexed	☐	☐
f) elbow flexed, hand fisted	☐	☐
3. **Protective Extension - Backward** - circle start position: ring sit kneeling other ______		
a) elbow extended, hand open	☐	☐
b) elbow extended, fingers flexed	☐	☐
c) elbow extended, hand fisted	☐	☐
d) elbow flexed, hand open	☐	☐
e) elbow flexed, fingers flexed	☐	☐
f) elbow flexed, hand fisted	☐	☐

✔ ☐ ✘ ☐ NT ☐

Scoring for Part D: PROTECTIVE EXTENSION *(page 13 only)*

Total ✔ : ☐ = l

Total ✘ : ☐ = m

Total NT : ☐ = n

TRANSFER TO QUEST SCORING SHEET ON PAGE **iv**

E: HAND FUNCTION RATING

Please rate this child's hand function (circle a number)

Guidelines for scoring hand function:

POOR: minimal independent hand grasps, no active release, unable to combine reach and grasp
GOOD: spontaneous reach, grasp and release, good eye-hand coordination

	POOR										GOOD
Left Hand	0	1	2	3	4	5	6	7	8	9	10
Right Hand	0	1	2	3	4	5	6	7	8	9	10
Bilateral	0	1	2	3	4	5	6	7	8	9	10

F: SPASTICITY RATING

Please rate this child's spasticity

Guidelines for scoring spasticity:

MILD: good spontaneous movement, normal tone at rest, associated reactions present
MODERATE: tone interferes with spontaneous movement, may be present at rest
SEVERE: minimal spontaneous movement, stiff limbs, tone present at rest

	NONE	MILD	MODERATE	SEVERE
Left Hand	☐	☐	☐	☐
Right Hand	☐	☐	☐	☐

G: COOPERATIVENESS RATING

Please rate this child's level of cooperation during this assessment.

NOT cooperative	SOMEWHAT cooperative	VERY cooperative
☐	☐	☐

QUEST *Scoring Sheet*

A. DISSOCIATED MOVEMENTS

1. Transfer score information from page 6 of QUEST.

Total ✔	= [ ]		= a
Total ✘	= [ ]		= b
Total NT	= [ ]	x 2	= c

2. Calculate unstandardized score.

$$\text{Score A} = \frac{2(a) + b}{128 - c} \times 100$$

c **a** is multiplied by 2 because each ✔ scores 2 points.

$$\text{Score A} = \frac{2(\quad) + (\quad)}{128 - (\quad)} \times 100$$

c The **128 - c** calculation adjusts the score for any items not tested.

Score A = [ ]

c Round to two decimal points.

3. Obtain a standardized score ranging from zero to 100.

(Score A - 50) x 2 = (- 50) x 2 = [ ]

This is the dissociated movements score and can be transferred to the front page of the QUEST.

B. GRASP

1. Transfer score information on sitting posture from page 7.

Total Normal	= [ ]	x 2	= d
Total Atypical	= [ ]	x (-1)	= e
Score B1 = d + e	= [ ]		

2. Transfer score information on grasps from page 10.

Total ✔	= [ ]		= f
Total ✘	= [ ]		= g
Total NT	= [ ]	x 2	= h

3. Calculate unstandardized score.

$$\text{Score B} = \frac{\text{Score B1} + 2(f) + g}{54 - h} \times 100$$

c The **54 - h** calculation adjusts the score for any items not tested.

$$\text{Score B} = \frac{(\quad) + 2(\quad) + (\quad)}{54 - (\quad)} \times 100$$

Score B = [ ]

c Round to two decimal points.

4. Obtain a standardized score ranging from below zero (if a child scores ✘ on all items and has atypical posture) to 100.

(Score B - 50) x 2 = (- 50) x 2 = [ ]

This is the grasps score and can be transferred to the front page of the QUEST.

C. WEIGHT BEARING

1. Transfer score information from page 12 of QUEST.

Total ✔	= ☐		= i
Total ✘	= ☐		= j
Total NT	= ☐	x 2	= k

2. Calculate unstandardized score.

$$\text{Score C} = \frac{2(i) + j}{100 - k} \times 100$$

c The **100 - k** calculation adjusts the score for any items not tested.

$$\text{Score C} = \frac{2(\quad) + (\quad)}{100 - (\quad)} \times 100$$

Score C = ☐

c Round to two decimal points.

3. Obtain a standardized score ranging from zero to 100.

(Score C - 50) x 2 = (- 50) x 2 = ☐

This is the weight bearing score and can be transferred to the front page of the QUEST.

D. PROTECTIVE EXTENSION

1. Transfer score information from page 13 of QUEST.

Total ✔	= ☐		= l
Total ✘	= ☐		= m
Total NT	= ☐	x 2	= n

2. Calculate unstandardized score.

$$\text{Score D} = \frac{2(l) + m}{72 - n} \times 100$$

c The **72 - n** calculation adjusts the score for any items not tested.

$$\text{Score D} = \frac{2(\quad) + (\quad)}{72 - (\quad)} \times 100$$

Score D = ☐

c Round to two decimal points.

3. Obtain a standardized score ranging from zero to 100.

(Score D - 50) x 2 = (- 50) x 2 = ☐

This is the protective extension score and can be transferred to the front page of the QUEST.

APPENDIX 7. Curriculum Vitae

1. Adı Soyadı : Ezgi KOYUNCU

İletişim Bilgileri **:** Küçükbakkalköy Mah. Ahmet haşim Sok. NO:4 D:14 Ataşehir/İSTANBUL

Telefon **:** 0537 382 97 07

Mail: : koyuncu.ezgi@hotmail.com

2. T. C Kimlik Numarası :16924600974

Ve Doğum Tarihi : 28.04.1991

3. Unvanı **:** Fizyoterapist

4. Öğrenim Durumu

	Mezun olduğu kurumun adı	**Mezuniyet yılı**
	İzmirYahya kemal Beyatlı ilkokulu	**2005**
	İzmir Bornova Anadolu Lisesi	**2009**
Lisans	Yeditepe Üniversitesi /Sağlık Bilimleri Fakültesi Fizik Tedavi ve Rehabilitasyon Bölümü	**2015**
Yüksek lisans	Yeditepe Üniversitesi /Sağlık Bilimleri Enstitüsü Fizik Tedavi ve Rehabilitasyon Bölümü	**Devam etmekte**

5. İş Tecrübesi

Özel Dört Mevsim Özel Eğitim ve Rehabilitasyon Merkezi 2015-2016

RİBEM Riskli Bebek Danışma Merkezi 2016- Devam etmekte

6. Katıldığı Kurslar Ve Eğitim Programlar

KATILDIĞI KURS VE SEMİNERLER	TARİH	SÜRE	KURUM
“Authorized Theratogs Fitter Certificate”	10 Aralık 2016/İstanbul	8 saat	Doğru Adımlar Medikal Eğitim Merkezi
Trigger Point Manuel Therapy and İntramusculer Manuel Therapy	19-20 Aralık 2015,İstanbul	16 saat	Prof.Dr Ali Cımbız
Nörolojik Fizyoterapi ve Rehabilitasyon Sempozyumu,’’Nöroplastisite ve Motor Öğrenme”	26 Şubat 2015 ,İstanbul	8 saat	İstanbul Üniversitesi
Üst-Alt Ekstremite ve Omurga Bantlama Teknikleri Kursu,Kinesiotaping Method	13-14 Aralık 2014/İstanbul	16 saat	Osman Şahin,B.Sc.PT.MT.MTD
Lumbar,Servikal ve Torasik Bölge Tedavi,Değerlendirme,Manipülasyon ve Mobilizasyon Kursu	20-21 Aralık 2014/İstanbul	16 saat	Osman Şahin,B.Sc.PT.MT.MTD
2.Yeditepe Üniversitesi Sempozyumu,Suyun Fizyoterapideki Yeri-Halliwick Yöntemi ile Suda Eğitim Çalıştayı	3 Şubat 2012	8 saat	Yeditepe Üniversitesi