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Research Article

Efficacy of Seat Surface Inclination on Postural Control During Reaching in Sitting Position in Normal Children

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Abstract

Background: Children are involved in many activities in sitting position such as reading, writing, playing and other related activities for a long duration (4-5 hrs) during day, The aim of the study to determine the efficacy of inclined seat surface on postural adjustments in sitting position during forward reaching in normal children. Fifteen Typically developing children were studied in three conditions: sitting with the seat surface oriented horizontally, sitting with the seat surface tilted 15 degrees forward and 15 degree backward.

Methods: postural muscle activity were recorded using surface electromyograms during reaching in the 3 conditions in addition to modified paediatric functional reaching test is done to determine which seat surface reflect the maximum postural control ability and stability in the 3 condition.

Results: The result suggest that in terms of postural muscle activity, backward inclined associated with more muscle activity than forward inclined surface and horizontal surface position while forward inclined associated with less muscle activity and more postural control ability in terms of modified paediatric reaching test.

Conclusion: In children who are typically developing, forward inclined seat surface is best position as it is associated with less postural activity and more postural control ability and stability during forward reaching.

Keywords: Seat; Inclination; Normal Children; Tilting Seat; Postural Control; Postural Adjustments Reaching; Sitting Position

Introduction

Sitting is a typical posture of the resting human body which allows individual to reduce energy consumption while being involved in communication, eating or working by using his hands. Sitting allows us to use our upper extremities in an intensive and concentrated way [1].

Active sitting requires postural control which is the ability to control the body's position in space for the purposes of stability and orientation, Postural stability, or balance, is the ability to maintain and/or regain the centre of mass within the base of support. Postural orientation is the ability to attain and maintain an optimal functional relationship between body segments, a task, and the environment [2].

The ability to control sitting balance gradually emerges in children with typical development during the period from about 2 to 9 months of age, with head control developing first, followed by progressive development of trunk control [3]. Reaching is a task involving extensive neural circuitries, in which primary motor, somatosensory cortices, frontal and parietal areas play prominent roles. Successful reaching requires postural control, either in the form of an active regulation of posture or in the form of postural support [4].

Proper upright sitting posture encourage effective performance of the daily activities, it was suggested that seat surface inclination have impact on pelvic tilt, balance and muscle activity which affects postural adjustment in sitting position during reaching in children [5].

The prescription of appropriate seating equipment like blocks and inclined wedges for normal children and young people is important to improve function that helps the child to increase his participation in social life, maintaining skeletal alignment, prevent, accommodate or correct skeletal deformity, provide stable base of support, increased tolerance to sitting position, promote comfort and relaxation [6,7].

There are conflicting opinions regarding to seat inclination in several studies, some support forward inclined sitting position as it has been suggested to reduce kyphosis, maintenance of lumbar lordosis as the centre of gravity shifted forward, decreased posterior pelvic tilting on the position of pelvis, reduce the effects of tight hamstring and position a person during reaching on desk or table for more upright and stable sitting posture [8-11]. Others support the backward inclined position as it decrease the pressure on the ischial tuberosity [12] or the spine, improve head and trunk posture [13], other concerns mentioned that seating that is excessively tilted backward limits communication, upper limb function and the ability to stand up from chair [13].

Postural function has been assessed by using electromyography (EMG) recordings of muscle activity controlling posture. The magnitude of anticipatory and postural muscle activity with voluntary movements have been measured by EMG amplitude analysis [14]. The amplitude of the EMG signal is an indicator of the magnitude of muscle activity, and is produced by increases in the number of active motor units and the frequency of activation [15]. Naturally, EMG amplitude increases as the intensity of muscle contraction increases. However, the relationship between EMG amplitude and force frequently is nonlinear [15].

Paediatric modified functional reaching test is a highly useful, valid, reliable, quick, simple test used to measure amount of forward and side reaching with movement of trunk which reflect the postural control ability and stability by amount of reaching [16,17].

Previous research suggested that a horizontal orientation of the seat is advantageous because it is associated with reduced muscle activity of lumbar extensors and hip adductors and with better upper extremity function [18], other studies found that the forward inclined result in better postural stability and less muscle activity [19] while posterior inclination associated with more muscle activity but may be useful as it offers biomechanical compensation for the forward sway [20].

Overall there is a lack of quality of evidence to support and guide which position is highly recommended for school children as they spend long hours sitting doing their activities, our study aims to determine which siting seat surface either horizontal or forward or backward inclined associated with more postural control and less postural muscle activity to ensure proper posture, comfort.

Subjects

Fifteen typically developed right handed children with age from 7 to 9 years were recruited from elementary schools of normal children who were apparently normal without any physical, neurological, visual or auditory problems. The study was done in gait laboratory at National Institute of Neuro Motor System; the children parents gave informed consent with procedure of the study. The protocol of this study approved by the ethical committees of the Faculty of physical therapy, Cairo University, Egypt.

Instrumentation

Kinetic analysis involves electromyograms (EMGS) with trigon wireless EMG system consists of Delsys Surface EMG Sensors which is fixed parallel bar design, contoured shape, and convenient adhesive skin interfaces allow for consistent and hassle-free recordings, base station, delsys EMG software for acquisition and analysis of data, Modified paediatric functional reach test which adapted for children in sitting position.

Procedure

The children sat on rounded table without back support and adjustable foot support, they were dressed in light clothes, an attractive bright coloured object was placed in front of the child in the midline at arm's length at the level of his/her shoulder to encourage the child to perform unilateral forward flexion to the object with shoulder flexion 90 degrees with the dominant hand, which defined as the hand preferred to write and draw. Children instructed to look directly forward and reach the toy with right hand in normal speed and in a self-paced mode after a computerized go-tone. Participants moved and stopped their arms at a horizontal position for about 5 sec returning to the original position and instructed to maintain a fully extended position during arm movement, the children were tested under 3 conditions, they started in the standard sitting position on the table, which is characterized by horizontal orientation of the seat surface (condition1), In two other condition a wedged platform was placed on the table which creates inclination 15 degrees. The children are instructed to sit on the wedge which inclined in forward direction and then in backward direction, Participants performed three trials with interval 5 sec rest between each trial for the three conditions. The seat surface is manufactured and its dimensions is executed by taking average depth from back of the buttocks to back of the knee and the width by measuring widest area of hip normal children from 7 to 9 years). Delsys EMG sensors were placed over the following muscles on the dominant side of the body of the, anterior deltoid (AD) which act as focal muscle of arm flexion, sternomastoid (NF) which act as neck flexors, upper trapezius as neck extensors, thoracic extensors at level T10 bilateral, lumbar extensors at level l5 bilateral, rectus abdominals unilateral on the side of reaching. Thoracic extensors and lumar extensors EMG signals are recorded bilaterally to record the activity of the muscles at both sides as previous studies indicated that higher EMG activity estimated from thorasic and lumbar extensors unilaterally in backward reclined position [19,20]. Leg muscle activity was not analysed, as previous studies as it is found that in typically developing sitting infants leg muscle activity is not related to postural control [21-23].

EMG analysis

EMG Root Mean Square (RMS) amplitude was measured to quantify the magnitude of postural muscle activity (rt stern mastoid,, rt upper trapezius, rt thoracic extensors, lt thoracic extensors, rt lumbar extensors and lt lumbar extensors) and it is expressed during burst activity of deltoid, the main flexor of shoulder, it is done by measuring the activity in window of burst activity of the deltoid after the onset of reaching.

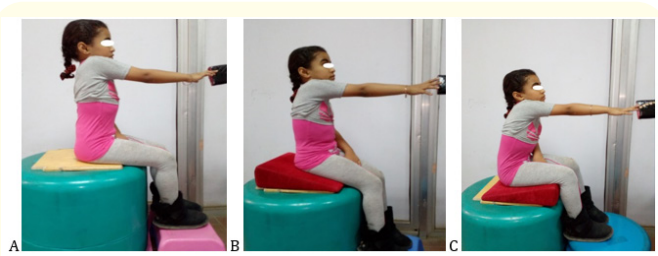

Figure 1: The figure shows typically developed child is sitting on horizontal [A], forward inclined 15 degree surface [B], backward inclined 15 degree surface [C].

The EMG data was normalized by measuring root mean square amplitude of submaximal voluntary contraction for each muscle divided by root mean square of maximum voluntary contraction (MVC) of the same muscle divided by 100, the output is displayed as percentage of % MVC [24], can be used to easily establish a common background when comparing data. MVC normalization can be used to eliminate variance and allow data comparison between subjects to take place [25].

Statistical analysis

Analysis of variance (ANOVAS) used to determine the effect of the condition of the seat surface on amplitude of postural muscle activity and postural control ability in terms of forward reaching test during reaching in normal children, throughout the analysis, we considered differences with p values <0.05 as statistically significant and p values<0.01 as highly statistically significant, post hoc analysis is used to determine the loci of significance for this analysis.

Results

The present study shows there is a variable effect of seat surface inclination on muscles controlling posture, there was no statistical significant difference for all postural muscles included in the study except right thoracic extensors and right lumbar extensors shows highly statistical significance between the three positions during reaching movement in normal children as shown in table (1), post hoc analysis shows that there is significant difference among the activity of rt thorasic and rt lumbar extensors between backward versus horizontal, forward position versus backward and horizon-

tal versus forward with p value <0.05 and this reveal that backward tilting position is associated with more muscular effortas shown in table (2).

For Modified Functional Reaching test, ANOVA shows there is a statistical significant difference between the three positions in normal group as shown in table (3), post hoc analysis shows significant difference between horizontal versus forward, backward versus horizontal with p value < 0.05and this means that forward inclined position associated with more forward reaching and postural control ability and stability in comparison to backward inclined position and horizontal positionas shown in table (4).

	Horizontal surface	Forward inclined surface	Backward inclined surface	F value	P value
Rt stern mastoid	3.68 ± 2.98	2.8 ± 2.34	3.7 ± 2.34	0.013	0.988
Rt Upper trapezius	19.3 ± 85.99	24.09 ± 21.2	34.48 ± 15.88	2.321	0.117
Rt thorasic extensors	40.34 ± 21.33	23.28 ± 20.99	60.9 ± 14.3	10.912	0.000**
Lt thorasic extensors	10.73 ± 8.43	7.9 ± 6.24	16.23 ± 10.94	2.342	0.115
Rt lumbar extensors	31.88 ± 19.04	17.91 ± 15.2	60.63 ± 12.15	1.295	0.000**
Lt lumbar extensors	8.17 ± 5.44	10.37 ± 16.04	18.88 ± 14.9	1.561	0.228
Rt rectus abdominis	7.05 ± 10	7.63 ± 11.85	10.23 ± 12.92	0.006	0.994

Table 1: Represents the mean values of the amplitude of postural muscle activity in typically developed child.

** = highly statistically significant.

	P value	
	Rt thorasic extensors	RT lumbar extensors
Horizontal vs forward	0.021*	0.041*
Forward vs backward	0.032*	0.003*
Forward vs backward	0.001*	0.023*

Table 2: Post hoc analysis Tests for comparing the activity of muscles of significant values among three positions during reaching in normal group**.** * statistical significant * * = highly statistically significant.

	Horizontal surface	Forward inclined surface	Backward inclined surface	F value	P value
Modified pediatric functional reaching test	30.56 ± 3.21	37.56 ± 4.096	20.56 ± 3.66	10.12	0.000**

Table 3: Represents the mean values for Modified Paediatric Functional Reaching test in normal child.

Horizontal vs forward	0.032*
Forward vs backward	0.021*
Forward vs backward	0.447NS

Table 4: Post hoc analysis for Modified functional reaching test among three positions. *significant, NS: nonsignificant.

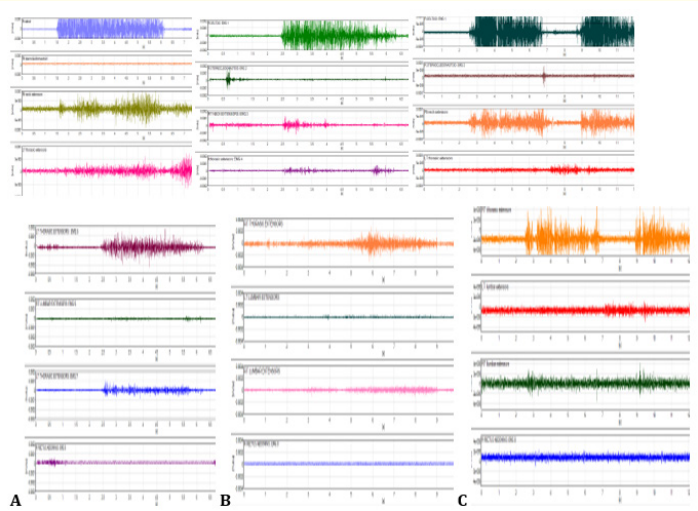

Figure 2: Representative EMG data for activity in focal muscle (right anterior deltoid) and postural muscle activity during reaching in sitting position on horizontal surface [A], forward inclined surface [B] and backward inclined surface [C] The muscles are shown in the graph are rt anterior Deltoid, rt sternomastoid, rt upper trapezius, lt thorasic extensor, rt thoracic extensors, lt lumbar extensors, rt lumbar extensors, rt rectus abdominals respectively.

Discussion

The present study is done to determine the efficacy of seat inclination on postural control in sitting position during reaching, the inclination used in the seat is 15 degrees as previous literature states that Above 15° of pelvis tilt, individuals with righting reactions, start trunk flexion in an attempt to maintain balance against gravity due to changes in body orientation. Thus, it can be said that above 15° of pelvic tilt the movement is not only from the hip but also from the spine Therefore, the maximum angle of adjustment of the seat in all planes was defined by 15° to ensure that the alignment would be only pelvic, but keeping the trunk free to make equilibrium responses and the righting reactions necessary for postural maintenance [26].

In this study the participants were involved in this study from age 7 to 9 years at this age postural adjustment becomes comparable to adult pattern and stability limits of postural control approaches to adult levels at age of 7 years old [27,28].

In previous studies [29,30] stated that if the seat tilt sloping forward it encourages nature posture as opposing muscle group are balanced and lumbar curve is preserved, this produces balanced seating in which the joint angles are open, the back is straight with lesser activity of back extensors muscles and this concur with our study as there is significant difference between the activity of right thoracic extensor and right lumbar extensors on the side of reaching among the three positions with forward inclined position associated with least activity as shown in post hoc analysis in comparison to backward and horizontal positions l.

In our study, forward inclined seat surface sitting position, associated with postural muscle activity especially in rt thoracic extensors and lt thorasic extensors and this could be explained by the centre of gravity passes slightly forward over sitting bones which creates anterior momentum counterbalanced by force created by extensors [31] but with lesser activity, In this position anterior pelvic tilting is occurred and lumbar lordosis is preserved [32] and this is useful for normal children to maintain upright posture.

In backward inclined position, Thoracic extensors shows greater activity with mean value (60.9 ± 14.3) than the forward inclined position this is because the centre of gravity passes backward over the sitting bones so the child tends to fall backward so he leans forward then he uses back extensors for re alignment of posture as the posture in this position becomes kyphosis, backward inclined position is associated with posterior pelvic tilting and flattening in lumbar region., and this agrees with previous studies [33,34].

In our study we had expected that backward inclined would be the more efficient position as it backward inclination would offer a counterbalance to forward body-sway induced by reaching movement, the unexpected result might be explained that the passive advantage of backward tilting was eliminated by the risk that the centre of mass would pass the stability limits, a risk which was induced by relatively degree of backward inclination (15degree). it may be possible that lesser degrees of backward tilting would result in more efficient postural activity. In backward inclined position, there is a great tendency to sit on the sacrum and this decrease the limits of stability [35].

Post hoc analysis shows that modified paediatric reaching test reveals significant difference among forward versus horizontal and backward versus forward and this states that forward associated with more forward reaching in comparison with the other 2 positions and this could be explained by forward inclination of the seat creates a degree of forward tilt of pelvis and this will be easier for upper body to come forward. While in backward tilting is associated with posterior pelvic tilting and the process to come forward can likened to do sit up from reclined position [36].

Conclusion

The present study showed that 15 degrees forward inclination was in terms of postural efficiency more efficient than the horizontal and 15 degree backward tilted sitting position as it is associated with lesser postural muscle activity and better postural control ability in terms of modified paediatric reaching test.

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