CHANGES IN NECK BIOMECHANICS THROUGHOUT CHILDHOOD

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INTRODUCTION

Chronic neck pain is a global, rising problem and its association with reduced neck muscle strength (NMS) (1) and with neck postural abnormalities (2,3) have already been published in adults. Therefore to obtain data was supposed to be important already in the school age, to anticipate the chances and risks of degenerative spine diseases. Concerning neck posture measurement in children, we have only found two studies on schoolchildren's posture between the ages of 6-12, in standing position (4,5). A lot of data are available on measuring isometric NMS in adults with different instruments and in different anatomical angles (6-21). Under the age 18, we have found only one study in which a group of 14-24-years olds have been measured, but only in extension, lying prone (16).

To evaluate the posture first the "physiological posture" should be defined, but no general agreement exists. We accepted the term "natural head position" as was suggested in cephalometry (22), and was used by Fiebert et al. 1999 (9). In previous studies the craniovertebral angle (CVA) (23), the head tilt angle (HTA) (244) and shoulder position (2,23) (SHA=shoulder angle) have been evaluated. Our study was designated to determine preliminary data on neck posture in children in sitting position by measuring the angles mentioned. A strain gauge dynamometer was used to measure maximal isometric NMS in five directions; flexion, extension, lateral flexion to both side and "nodding". This latter test was aimed to gain "some" information on the strength of the deep flexors.

METHOD

Subjects were fifty 9-year old schoolchildren and thirtyfour 16-year olds who were attending public school at different districts of Budapest. Informed consent was obtained from each

child and their parents, and approval was also obtained from the institution's ethics committee.

Digital photographs were taken of the children seated in a straight-high-backed chair, pushing their shoulders against the back of the chair, thus the motion of the dorsal spine could be avoided. The following anatomical landmarks were identified by small colored adhesive markers: the tragus of the ear, C7 spinous process, and the base of the nose. The camera was located perpendicular to subject's position from the left side, the focus was on the tragus with a standard distance of 150 cm. Digital photo was taken in the "neutral head position" and was evaluated by a computer software program, which enabled the use of standard protocols for digitizing the angles from the photographs. The angles analyzed were as follows: CVA= between the line connecting the tragus and C 7 spinous process and the x-axis, the HTA= between the line connecting the tragus and the base of the nose and the y-axis, shoulder angle (SHA)= between the line connecting the acromion and C 7 spinous process and the x-axis (Figure 1.).

Isometric muscle strength was measured by a battery-powered strain gauge dynamometer device, which was fixed on one side to the wall and on the other side to the subject's head by a helmet. The children were stabilized by a belt around their thighs and they were held by their shoulders by a physiotherapist, who controlled the procedure in order to make sure only the neck muscles were used. The subjects pulled the dynamometer with their head and always turned in the appropriate direction. The measurements were performed sitting, with the "neutral head position". The maximal isometric force (breaking force) was measured in nodding, flexion, extension, lateral flexion to the right and to the left. Each motion was performed for 10 seconds, with resting intervals of 20 seconds and was repeated 3 times. The measurements were expressed in Newton (N), the device's measuring rate was between 1-250 N, with a minimum rate 1 N. An average of the efforts in each direction was calculated and than they were summed up to a value of total neck muscle strength. Grouping of the total neck muscle strength was calculated by cluster analysis (25) .

Antropometric data included measuring weight and height, that were calculated into BMI (Body Mass Index).

Reliability study

All measurements were repeated two times on the same day (with an hour interval) by two different pairs of physiotherapists and the third time the next day by the entire group.

The correlation coefficients and the results of Friedmann's test indicate a sufficient reliability (correlation coefficients between 0,8133 and 0,9069, $P<0.05$).

RESULTS

1. Basic data (weight, height, BMI) by gender are shown on Table 1. They well demonstrate the developement of the children.
2. The data concerning neck posture angles are shown in Table 2. The comparison of the data in the two groups demonstrated that in the 16-year olds CVA values have been found reduced by an average of 8 degrees and the HTA elevated by an average of 1,6 degrees. That means, that neck posture changed into forward flected position. The elevation of the SHA by an average of 13,33 degrees referres to more protracted shoulders.
3. The isometric neck muscle strength data into five directions are shown in Table 3. The NMS into flexion was found weaker than into extension and generally the same values were found in flexion as in lateral flexion, the ”nodding” strength proved to be one third-half of the force effected in flexion.
4. The total neck muscle strength by gender are shown in Table 4. The neck muscle strength values have been found increased with aging. The 9 year old girls’ neck proved to be slightly stronger than the boys’ ones, but at the age of 16 boys turned to be stronger.
5. Grouping of the total neck muscle strength by cluster analysis is shown on Table 5. It suggested a rather high proportion of “weaks” in each age group.

DISCUSSION

Although some authors doubts the objectivity of angles measured by photographs (26,27), our data are in correlation with the relevant literature. The numerical values of age-matched children previously published were slightly lower (4,5), but that difference is due to the difference that they were measured standing. The CVA has been published to be in average 51,97° in adults (23), which is approximately equal to our mean data with the 16 year old group. HTA was found (by video recording) in adults 57 ° (24), that was lower than our mean data with children. The SHA values measured by us were in the range of the data published in

adults (2). The higher degree of SHA referred to the clinical symptom, that should be called “rounded shoulder”. The angles measured were characteristic to what can be seen in real life. The comparison of the data found in the two age groups might demonstrate either a tendency to “poorer posture” or the natural process with aging, which needs further studies.

Our data on isometric neck muscle strength in neutral sitting position were in correlation with the data published on adults. The measurement of the force in nodding has been only an attempt to investigate the function of deep flexors. On the basis of cluster analysis groups were determined, characterized as “strong”, “weak” and “medium”. These could not be unanimously defined, because of our relatively small cases. More studies are needed to determine the “normal” range of strength and the incidence of “weakness” in age matched groups of children. Our investigations supported the fundamental concept of need for preventive interventions on the cervical spine as early as possible.

Tables

Table 1. Mean values of weight, height and BMI by gender.

	GENDER		WEIGHT	HEIGHT	BMI
AGE 9	***MALE***	Mean	32.25	141.59	15.98
	(n = 32)	SD	5.81	6.96	1.99
	FEMALE	Mean	27.89	137.39	14.63
	(n = 18)	SD	5.72	7.94	1.81
AGE 16	***MALE***	Mean	68.67	178.39	21.54
	(n = 18)	SD	15.31	9.49	4.17
	FEMALE	Mean	61.25	169.63	21.26
	(n = 16)	SD	13.42	5.90	4.49

Table 2. CVA, HTA and SHA values.

Angles	AGE 9 : n = 50 AGE 16 : n = 34	MINIMUM (degree)	MAXIMUM (degree)	MEAN (degree)	SD
CVA neutral	AGE 9	40.00	84.00	60.30	11.02
	AGE 16	41.00	63.00	52.35	5.93
HTA neutral	AGE 9	42.00	87.00	68.26	8.98
	AGE 16	55.00	80.00	69.56	5.22
SHA neutral	AGE 9	91.00	123.00	106.41	8.33
	AGE 16	90.00	149.00	119.74	12.72

Table 3. Isometric neck muscle strength.

AGE 9 (n = 50) AGE 16 (n = 34)		**MINIMUM (Newton)**	**MAXIMUM (Newton)**	**MEAN (Newton)**	**SD**
„Nodding"	AGE 9	5.20	16.10	10.07	2.29
	AGE 16	5.40	22.20	10.36	5.51
Flexion	AGE 9	12.10	58.20	22.41	9.20
	AGE 16	10.50	78.30	32.14	15.38
Extension	AGE 9	9.33	40.60	25.62	7.12
	AGE 16	14.67	89.67	42.01	20.53
Lat. flexion - right	AGE 9	6.70	61.40	19.39	10.46
	AGE 16	11.33	71.30	28.25	13.10
Lat. flexion - left	AGE 9	5.33	48.20	19.16	8.64
	AGE 16	11.30	75.10	28.49	13.14

Table 4. Total neck muscle strength and gender .

		MINIMUM (Newton)	**MAXIMUM (Newton)**	**MEAN (Newton)**	**SD**
Male AGE 9 : n = 32 AGE 16 : n = 18	AGE 9	41.60	145.55	96.03	24.81
	AGE 16	103.80	286.70	174.44	54.72
Female AGE 9 : n = 18 AGE 16 : n = 16	AGE 9	51.50	206.10	97.76	45.21
	AGE 16	55.60	207.30	103.90	37.08

Table 5. Grouping on total muscle strength by statistical K-means cluster analysis.

	„WEAK”		„MEDIUM”		„STRONG”	
	n	Average strength [Newton]	n	Average strength [Newton]	n	Average strength [Newton]
AGE 9 n = 50	32	79.36	16	116.29	2	216.00
AGE 16 n = 34	14	89.60	14	149.98	6	241.39

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Figure 1. Angles characterizing neck posture.