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Original Article

Age-dependency of posture parameters in children and adolescents

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Abstract. [Purpose] Poor posture in children and adolescents is a well-known problem. Therefore, early detection of incorrect posture is important. Photometric posture analysis is a cost-efficient and easy method, but needs reliable reference values. As children's posture changes as they grow, the assessment needs to be age-specific. This study aimed to investigate the development of both one-dimensional posture parameter (body inclination angle) and complex parameter (posture index) in different age groups (childhood to adolescence). [Subjects and Methods] The participants were 372 symptom-free children and adolescents (140 girls and 232 boys aged 6–17). Images of their habitual posture were obtained in the sagittal plane. High-contrast marker points and marker spheres were placed on anatomical landmarks. Based on the marker points, the body inclination angle (INC) and posture index (PI) were calculated using the Corpus concepts software. [Results] The INC angle significantly increased with age. The PI did not change significantly among the age groups. No significant differences between the corresponding age groups were found for PI and INC for both sexes. [Conclusion] When evaluating posture using the body inclination angle, the age of the subject needs to be considered. Posture assessment with an age-independent parameter may be more suitable.

Key words: Posture parameters, Posture assessment, Children

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INTRODUCTION

Poor posture in children and adolescents is a well-known problem that can lead to negative consequences in adulthood[1–3)]. The assessment of posture in children and adolescents is a key point in the early identification of posture weakness and the introduction of preventive measures[4)]. An easy and cost-effective measurement technique is photogrammetry[5)]. Posture photos in the sagittal plane are evaluated by means of computer software, and the resulting values are applied for assessing the posture[6)]. The reliability and validity of this type of measurement has been well examined[7–10)]. The identification of key indicators of posture that can be directly assessed in a clinical setting is required for full assessment of the performance of the musculoskeletal system.

A key indicator that is easy to determine is the forward inclination of the trunk. Newer studies have shown that an increased body inclination angle is associated with back pain[11)]. Therefore, this parameter is of high clinical relevance.

A more complex measurement is the posture index[12)]. It calculates the distances of multiple anatomic landmarks of the trunk in a plumb line through the malleolus lateralis. The posture index describes the orientation of the trunk segments to each other, and thus, provides an evaluation of trunk stability.

During childhood growth, the body undergoes various development phases during which the body proportions change. It can therefore be assumed that individual posture parameters also change because of these development-based, biomechanical changes.

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Table 1. Anthropometric data and calculated posture parameters for the subjects (n=372). The last row shows significant differences ($p<0.05$) between the groups

	A	B	C	D	E	F	G	H
	Girls 6–8 yrs	Girls 9–11 yrs	Girls 12–14 yrs	Girls 15–17 yrs	Boys 6–8 yrs	Boys 9–11 yrs	Boys 12–14 yrs	Boys 15–17 yrs
	(n=17)	(n=42)	(n=52)	(n=29)	(n=20)	(n=79)	(n=89)	(n=44)
Weight [kg]	28.69 ± 5.68	36.93 ± 7.81	50.96 ± 10.33	58.18 ± 10.28	30.11 ± 9.09	36.65 ± 10.1	52.88 ± 1.42	64.71 ± 9.87
Height [cm]	129.53 ± 7.35	146.89 ± 8.38	162.24 ± 9.32	168.74 ± 8.42	132.37 ± 8.76	145.24 ± 9.78	165.93 ± 10.33	178.41 ± 7.28
Posture index PI [-]	1.15 ± 0.22	1.13 ± 0.21	1.14 ± 0.24	1.12 ± 0.19	1.20 ± 0.24	1.11 ± 0.21	1.10 ± 0.20	1.13 ± 0.15
Body incl. angle INC [°]	1.89 ± 1.58	1.94 ± 1.24	2.83 ± 1.30	2.80 ± 1.30	1.80 ± 1.22	2.10 ± 1.25	2.68 ± 1.42	2.93 ± 1.45
INC sign. diff. to group	C, D	C, D	A, B	A, B	G, H	G, H	E, F	E, F

The objective of the study was to determine whether the two posture parameters, trunk inclination angle and posture index, differ between children and adolescent age groups and between the sexes.

SUBJECTS AND METHODS

A total of 372 children and adolescents (140 girls, 232 boys) participated in the study (Table 1). The subjects were recruited within the framework of an interdisciplinary university research project exploring weak posture in children (KidCheck, Saarland University, Germany) The study included symptom-free subjects without orthopedic problems.

In accordance with the requirements of the Declaration of Helsinki, the test subjects and their parents or guardians were informed about the test objectives and procedure prior to testing, and they gave their written informed consent. The local ethics committee had approved the study.

All posture parameters were calculated based on posture images of the sagittal plane. For this, the test subjects undressed and high-contrast marker points or marker spheres (12 mm in diameter) were stuck onto the anatomical reference points as indicated in Fig. 1. The subjects were placed sideways in front of a measuring wall looking straight ahead. The measuring wall was used to calibrate the camera image on the horizontal plane. The subjects had been instructed to stand in a relaxed (habitual) posture, look straight ahead, and keep their arms to the side of their body. A posture image was obtained using a high-resolution camera (Olympus SP510UZ, resolution 2,304 × 3,072 pixels), which was placed on a tripod at hip-height.

The posture photographs were analyzed using the Corpus concepts software (AFG, Germany). The following posture parameters were calculated:

A. Body inclination angle INC: angle of the junction of marker 3 and 10 (Fig. 1) from the vertical[13].

B. Posture index PI: The posture index was calculated using (dK+dA) / (dB+dL), with the horizontal distances between the following anatomical landmarks and the plumb line each: dK = thoracic kyphosis (marker 6 in Fig. 1), dA = SIAS (marker 7), dB = sternum (marker 5), dL = horizontal distance lumbar lordosis (marker 8).

The statistical parameters were calculated using the WinSTAT for Windows Excel software. Descriptive parameters, such as mean values and standard deviations, were calculated for four age groups and for girls and boys individually. Possible differences between the age groups were calculated using variance analysis (one-way ANOVA) for INC and PI after applying Bartlett test for variance homogeneity. Subsequently, to check for possible differences between the sexes, independent t-tests were calculated. The significance level was set to $p<0.05$.

RESULTS

The results are presented in Table 1. All values were normally distributed within the different age groups. The posture index PI did not change significantly between the age groups, and no differences between boys and girls were identified for PI. The body inclination angle INC significantly increased with age. No significant differences between the same age groups of boys and girls were found.

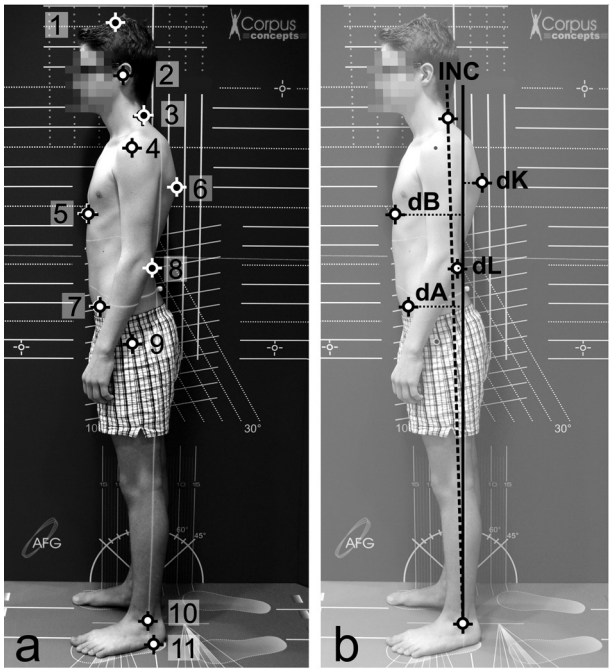

Fig. 1. a. Anatomical landmarks used in the study: 1: skull, 2: auditory canal, 3: C7, 4: acromion, 5: distal sternum, 6: maximum of thoracic kyphosis, 7: SIAS, 8: maximum of lumbar lordosis, 9: trochanter major, 10: malleolus lateralis, 11: sole of foot. b. Anatomical landmarks used to calculate the posture index PI (see text) and definition of the body inclination angle INC

DISCUSSION

In all age sub-groups, the average values of the posture index were in the normal range, spanning between 0.9–1.3[14]. The normal distribution of the values confirms that representative, healthy groups were tested. There were no age- or gender-specific differences. The regulation of the position of the trunk segments depends on muscular performance[15] and the quality of neuromuscular control[16, 17]. Since no changes in the posture index were identified during age development, it is safe to assume that the posture regulation tested with this parameter does not depend on biometric parameters that change due to growth.

In contrast, body inclination increased significantly with age, with the values identified corresponding on average to those determined in other studies[18]. This can be explained by height growth and the resulting geometric changes[19]. It is a known fact that forward inclination of the body is mainly determined by the angle of the ankle joint[20]. With a larger body height, the strength to be applied by the calf muscles is higher, which explains the increase in forward inclination during the major growth phases.

We can conclude that it is important to include the age of the subject in the interpretation of the body inclination angle. An assessment of posture using the posture index may be more suitable because this parameter is independent of age and gender.

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