PŮVODNÍ PRÁCE

FACIAL INDICES – METHOD OF AGE APPROXIMATION FROM PHOTOGRAPHIC MATERIAL

Tvárové indexy – metóda odhadu veku z fotografického materiálu

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Abstract

A steady increase in distribution of child pornographic material has been observed in recent years. Correct age approximation from this material is crucial for answering the question if person depicted on photography is under the age of legal prosecution and the time of sexual abuse of children. At the present, forensic scientists still use Tanner method of secondary sexual traits evaluation although the unreliability of this method was proven.

This study is inspired by previous projects which took part in Italy, Germany and Lithuania. The main aim of present study is to verify the method of facial indices for age evaluation from photographs of the children faces.

In this study, 149 facial pictures of children from 5 age categories (6–8 y., 9–11 y., 12–14 y., 15–17 y., 18–19 y.) underwent a metric analysis. Individuals were from Slovak Republic with no craniofacial trauma. Twenty-three indices (eighteen from frontal view and five from lateral view) were calculated from obtained measurements.

The age was correctly estimated in 16.23% in girls and in 26.42% in boys. The most appropriate indices for age approximation based on photographs were indices of width measurements (nasal and labial width, interpupillary distance, intercanthal width, biocular width) and indices of height measurements (nasal height and physiognomic upper facial height).

Keywords: *facial measurements, facial indices, facial growth, child pornography, age approximation*

Introduction

In recent years a great increase in the diffusion of child pornographic material has been observed. The progress of new technologies as a criminal tool is a serious problem leading to a profitable criminal business. Particularly, with regards to the increasing issue of this type of child abuse (Cattaneo et al., 2009; Cattaneo et al., 2012; Cummaudo et al., 2014; Europol, 2012; Ratnayake et al., 2013). For this reason, more and more, the approximation of age of the victims on 2D material plays an essential role for the legal implications concerning pornography.

The crime of child pornography is based on the specific ages each country considers as relevant. From 2003, any person under the age of 18 years in defines as being a child in this context within the European Union. Therefore, the difficulty lies in the assessment of child's age on photography and verifying whether the material is pedo-pornographic. The very important is also a time of sexual abuse of a child (Cattaneo et al., 2009; Ratnayake et al., 2013).

According to Cattaneo et al. (2012), until now, there is no scientifically established method for age evaluation based entirely on 2D images. The conventional methods such as evaluation of secondary sexual traits (Tanner method) or a possibility to evaluate dental eruption and development are highly limited and unreliable due to the large inter- and intra- individual variability (Ratnayake et al., 2013; Cunha et al., 2009).

For this reason, recent research, inspired by previous European projects already mentioned, is focused towards the study of facial parameters as age indicators. Based on the results, metric assessment of facial proportions on images could be used for forensic age approximation. In fact, there are age-related changes in facial growth, which can be observed in living individuals, are as well reflected in photographs. And secondly, the several indices taken from photographs correlate closely with age (Cattaneo et al., 2012; Cummaudo et al., 2014).

Aim

The aim of this study was to verify the applicability of facial indices in age approximation from photography of face and find the most appropriate indices for age approximation. The other aim of this study was to identify indices with the highest increment between the age categories.

Methodology

An anthropometric analysis is based on the sample of *in vivo* measurements of 291 girls and 249 boys aged between 6 and 19 years and of *in photo* facial measurements of 123 girls and 26 boys aged between 6 and 21 years (Table 1). Children have no facial pathologies or deformities and are from Slovak Republic.

In vivo measurements were realized at schools in Slovak Republic with previous written permission of parents. The *in vivo* measurements were defined according to Kolar and Salter (1996) and included: bifrontotemporal distance (ft-ft), bizygomatic width (zy-zy), interpupillary distance (pu-pu), intercanthal width (en-en), biocular width (ex-ex), nasal width (al-al), labial width (ch-ch), physiognomic upper facial height (se-sto), nasal height (se-sn), nasal bridge length (se-prn), nasal depth (prn-sn), physiognomic ear length (sa-sba), physiognomic ear width (pa-pra).

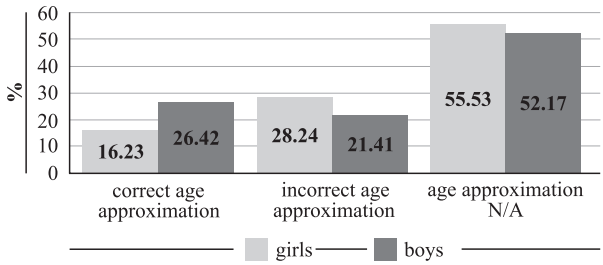
The statistical analysis of measured data was performed in Microsoft Excel 2007 and SPSS software, version 17.0 (SPSS Inc, 2008). Statistically significant differences in consequential age groups of girls and boys were tested with non-parametric Kolmogorov-Smirnov test. According to statistically significant differences between particular ages the sample of girls and boys was divided into 5 age categories: 6.00–8.99 years, 9.00–11.99 years, 12.00–14.99 years, 15.00–17.99 years and 18– 19.99 years (Table 1).

Next, 22 indices for each age category of girls and boys were calculated: seventeen indices in frontal view (sesn/pupu, pupu/sesto, enen/sesn, enen/sesto, sesn/exex, sesto/exex, alal/sesn, alal/sesto, chch/pupu, chch/exex, enen/chch, alal/chch, chch/ftft, sesn/ftft, sesto/ftft, sesn/zyzy, sesto/zyzy) and five indices

Table 1. *Distribution of children from in vivo and in photo measurements within different groups according to decimal age*

Age category (years)	In vivo measurements		Age category (years)	In photo measurements	
	girls	boys		girls	boys
	n	n		n	n
6.00–8.99	55	49	6.00–8.99	13	8
9.00–11.99	63	63	9.00–11.99	12	3
12.00–14.99	88	62	12.00–14.99	22	2
15.00–17.99	54	51	15.00–17.99	29	5
18.00–19.99	31	24	18.00–21.99	47	8
Total	291	249	Total	123	26

Figure 1. *The result of age approximation from in photo measurements of girls´ and boys´ faces*



in lateral view (prnsn/sesto, seprn/sesn, seprn/sesto, sesn/sesto, prapa/sasba). These indices were chosen on the basis of previous study of Cummaudo et al. (2014) and Cattaneo et al. (2012). Each index was defined as a ratio between two linear measurements (for example: index sesn/pupu was defined as a ratio between nasal height and interpupillary distance). For indices in each age category of girls and boys was calculated Minimum (Min), Maximum (Max), Mean (M.) and Standard deviation (SD). Based on the obtained results, equations for each index were calculated. They were used for the age approximation. *In vivo* measurements were used as a norm.

The set of facial photographs of known age is based on individuals who provided their photographs voluntarily. This sample is not standardized and there is no data set of *in vivo* measurements for each subject on photograph. Into the study were included photographs with faces oriented in frontal and lateral view. Photographs with faces oriented in the other view were excluded.

Next each facial photograph underwent metric analysis in software Digimizer, version 4.5.2 (MedCalc Software, 2011). First landmarks were placed on the photograph and then distances between two landmarks were measured. Measurements were the same as in the *in vivo* sample. Then, 22 *in photo* indices were calculated and were put into the equations to estimate the age. The result was then compared to known age of person depicted on photography.

Results

The result of age approximation by means of equations was one of five age categories (6.00–8.99 years, 9.00–11.99 years, 12.00–14.99 years, 15.00–17.99 years and 18–19.99 years) for each index. From the total number of approximations, the age was correctly estimated in 16.23% of indices in girls and in 26.42% of indices in boys (Figure 1). Correct approximation means that the estimated age category coincided with real age of person depicted in photograph. Age was estimated incorrectly in 28.24% in girls and in 21.41% in boys (the estimated age category did not coincided with real age of person depicted in photograph). In more than 50% the age was not estimated in girls and boys because of impossibility to calculate some indices (for example index sesn/ftft: if it was not possible to measure bifrontotemporal distance in the photograph, the value of index equated 0). Some distances was not possible to measure because of hair in the forehead, hair along the face, etc. After exclusion of those cases, the age was estimated correctly in 39.90% of all cases.

Figure 2 presents indices with the highest percentage of success in age approximation: sesn/pupu (28.86 %), enen/sesn (30.20%), sesn/exex (34.23%), sesto/exex (25.50%), alal/sesn (34.23%), chch/pupu (25.50%), chch/exex (27.52%). The success of the other indices was lesser than 25%.

The other aim of this study was to identify the time of the biggest changes in facial proportions in the consequential age groups of girls and boys. As seen in Table 2, the most statistically significant differences between indices were found between age categories 6.00–8.99 and 9.00–11.99 in girls and 12.00–14.99 and 15.00–17.99 in boys. The number of growth changes between other consequential age categories of girls and boys was lesser. Facial proportions in girls´ faces start to change earlier, from 6.00–8.99 to 9.00 11.99 years, whereas boys´ faces start to change later, from 12.00–14.99 to 15.00–17.99 years. Indices: sesn/pupu, chch/exex, chch/ftft, sesn/ftft, sesto/ftft in girls and sesn/pupu, chch/exex, sesn/exex, chch/pupu, chch/ftft, sesn/ftft, sesn/zyzy, sesto/zyzy in boys were increasing with age. Indices decreasing with age were the following: enen/sesn, enen/chch, alal/chch, prapa/sasba in girls and enen/sesn, enen/chch, and enen/sesto in boys.

According to these results, nasal height, labial width, physiognomic upper facial height and physiognomic ear length grow faster than interpupillary distance, intercanthal width, biocular width, bifrontotemporal distance, nasal width and physiognomic ear width in girls. In boys, nasal height, labial width, physiognomic upper facial height grow faster than interpupillary distance, intercanthal width, biocular width, bifrontotemporal distance and bizygomatic width.

Discussion

The issue of aging the people depicted in photographs and videos has become very important especially in cases suspected of child pornography. The correct age approximation is crucial in forensic practice, where the question of the age plays an essential role for the legal implications. Experts from forensic anthropology, pathology, pediatrics and other fields are often asked to estimate the age from photography or video. Current conventional methods (Tanner method of secondary sexual traits evaluation and method of dental status evaluation) are not sufficient. Because of inaccuracy of these methods, researchers have been trying to find the other way for age approximation. Their attention is focusing on the face and facial indices as the most suitable tool for age approximation (Cattaneo et al., 2012; Cunha et al., 2009; Schmeling & Black, 2010; Ratnayake et al., 2013; Kleinberg, 2008; Gibelli et al., 2012).

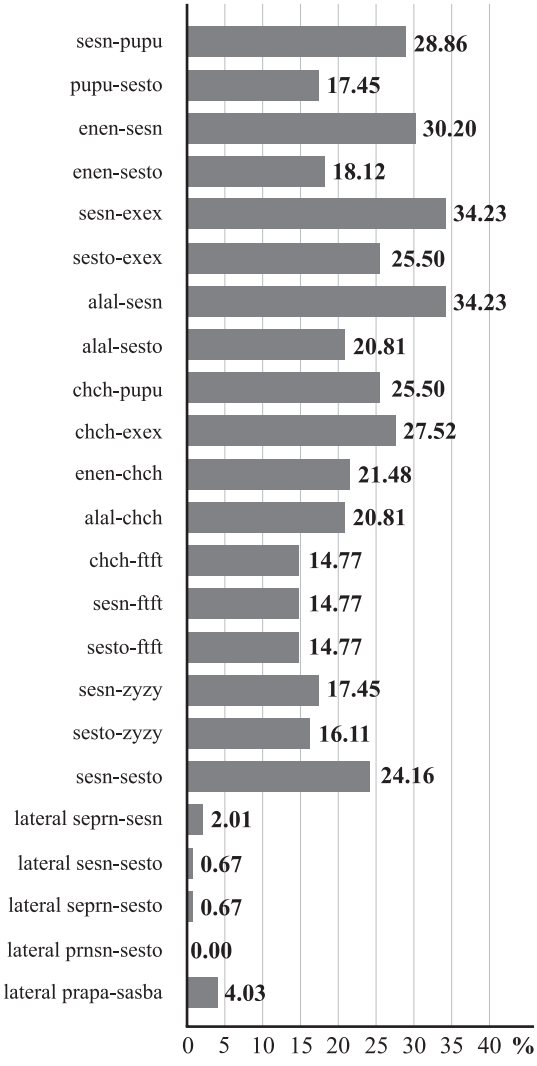
The use of facial indices is essential because the age-related changes in facial growth observed in living individuals are

Table 2. *The in vivo calculated indices with the highest increment in girls and boys from 6.00 to 17.99 years*

Indices	Girls		p-value	Indices	Boys		p-value
	6.00–8.99 y. (n = 55)	9.00–1.99 y. (n = 63)			12.00–14.99 y. (n = 62)	15.00–17.99 y. (n = 51)	
sesn/pupu	0.884	0.909	0.026*	sesn/pupu	0.910	0.952	0.015*
enen/sesn	0.660	0.618	0.034*	enen/sesn	0.648	0.600	0.008**
chch/exex	0.503	0.530	0.034*	enen/sesto	0.454	0.433	0.025*
enen/chch	0.692	0.635	0.003**	sesn/exex	0.552	0.578	0.001**
alal/chch	0.721	0.687	0.003**	chch/pupu	0.892	0.931	0.012*
chch/ftft	0.417	0.450	0.000***	chch/exex	0.541	0.564	0.000***
sesn/ftft	0.440	0.463	0.023*	enen/chch	0.662	0.613	0.004**
sesto/ftft	0.623	0.651	0.020*	chch/ftft	0.456	0.479	0.003**
prapa/sasba	0.590	0.553	0.011*	sesn/ftft	0.466	0.490	0.003**
–	–	–	–	sesn/zyzy	0.404	0.437	0.001**
–	–	–	–	sesto/zyzy	0.574	0.606	0.006**

*Note: p – statistical significance, * – p < 0.05; ** – p < 0,01; *** – p < 0,001*

Figure 2. *The success of indices in age approximation*



well reflected in photographs and several indices taken from photographs closely correlate with age (Cattaneo et al., 2012; Cummaudo et al., 2014).

According to our results, the age was correctly estimated in 16.23% in girls and in 26.42% in boys. The incorrect approximations were in 28.24% in girls and in 21.41% in boys. Remaining indices were not calculated because of impossibility to measure some distances *in photo* because of hair in the forehead, hair along the face, etc.

Indices with the highest level of success in correct age approximation were sesn/pupu (28.86%), enen/sesn (30.20%), sesn/exex (34.23%), sesto/exex (25.50%), alal/sesn (34.23%), chch/pupu (25.50%), chch/exex (27.52%) in girls and boys.

Our study documents that the most pronounced changes in facial proportions are observed between the following age categories: 6.00–8.99 years to 9.00–11.99 years in girls; 12.00–14.99 years to 15.00–17.99 years in boys. These results were in coincidence with our previous study (Beňová, Beňuš, & Cvíčelová, 2011). Facial structures that grow faster are: height of the middle face and labial width and structures, that grow slower are: eyes, bifrontotemporal and bizygomatic width.

Conclusion

The study presents an innovative method for age approximation from photographs of children faces based on the facial indices. With the use of equations, age was correctly estimated in 16.23% in girls and 26.42% in boys. In more than 50% the age was not evaluated at all. This number is caused by hair in the forehead, hair along the face, glasses, etc.

The most appropriate indices for age approximation according to our study were: sesn/pupu, enen/sesn, sesn/exex, sesto/exex, alal/sesn, chch/pupu, chch/exex.

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Súhrn

Primárnym cieľom štúdie bolo overiť použiteľnosť metódy rovníc pri odhade veku z fotografie tváre jedincov. Vek bol správne odhadnutý v 16,23 % dievčat a v 26,42 % chlapcov. V 28,24 % bol u dievčat odhadnutý vek nesprávne a u chlapcov v 21,41 %. Vo viac ako 50 % prípadov nebolo možné vek odhadnúť vôbec, nakoľko sa nám nepodarilo na fotkách zmerať všetky rozmery kvôli vlasom pozdĺž tváre, ofine, atď.

Indexy, ktoré sa javia ako najúspešnejšie a najvhodnejšie pre odhad veku sú: sesn/pupu, enen/sesn, sesn/exex, sesto/exex, alal/sesn, chch/pupu, chch/exex. Sú to predovšetkým indexy šírkových (šírka pier a nosa, vzdialenosť vonkajších a vnútorných očných kútikov a medzizrenicová vzdialenosť) a výškových rozmerov (výška nosa a fyziognomická výška hornej tváre) strednej časti tváre.

Predložená štúdia prezentuje výsledky týkajúce sa rozdielov v raste dievčenských a chlapčenských tvárí. Tváre dievčat rastú

intenzívnejšie v rozmedzí od 6.00–8.99 rokov do 9.00–11.99 rokov, po tomto období už rast nie je taký intenzívny. Štruktúry tváre, ktoré rastú u dievčat v tomto veku najviac, sú výškové rozmery strednej časti tváre a šírka pier. U chlapcov nastupuje špurt v raste tváre neskôr, v rozmedzí od 12.00–14.99 rokov do 15.00–17.99 rokov, v období, keď sa u dievčat spomaľuje. Štruktúry, ktoré rastú intenzívnejšie sú podobne ako u dievčat výškové rozmery strednej časti tváre. Pomalý rast bol v skupine dievčat a chlapcov zaznamenaný v oblasti očí a šírkových rozmeroch tváre.

Kľúčové slová: *rozmery tváre, tvárové indexy, rast tváre, detská pornografia, odhad veku*

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