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RAPPORT

EN SYSTEMATISK OVERSIKT

Samsvar mellom kronologisk alder og skjelettalder ba[...] Greuli[...]

Agreement between chronological age and bone age based on the Greulich and Pyle atlas for age estimation: a systematic review

This is an excerpt from the full technical report, which is written in Norwegian. The excerpt provides the report's main messages in English.

folkehelseinstituttet

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Key messages (English)

The Greulich and Pyle atlas is used to estimate the age of children and adolescents. This systematic review summarizes the scientific evidence on the agreement between skeletal age from the Greulich and Pyle atlas (hereafter called GP skeletal age) and chronological age.

A total of 17 studies met our criteria. 13 studies presented results for GP skeletal age from chronological age, 2 presented results for chronological age from GP skeletal age and 2 were datasets which we used to present both types of results. These two approaches are not comparable and we have therefore conducted two separate analyzes.

The difference between GP skeletal age and chronological age was on average rarely more than one year for each age group.

The studies that presented the distribution of chronological age from GP skeletal age are the most relevant if the Greulich and Pyle atlas is used for age estimation. Here we did no meta-analysis, since results from three of the four studies were so affected by the phenomenon «age mimicry» that we do not have confidence in the results. We considered that only one study was conducted in such a way that it can adequately describe the method's ability to estimate age.

Title:
Agreement between chronological age and bone age based on the Greulich & Pyle-atlas for age estimation: a systematic review.

Type of publication:
Systematic review

A review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review. Statistical methods (meta-analysis) may or may not be used to analyse and summarise the results of the included studies.

Doesn't answer everything:

- Excludes studies that fall outside of the inclusion criteria
- No health economic evaluation
- No recommendations

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- Bjørn Anton Graff, Research leader, Diagnostics, Vestre Viken HF
- Lil-Sofie Ording Müller, Consultant Paediatric Radiologist, Oslo University Hospital

Executive summary (English)

Background

Every year, young unaccompanied asylum seekers arrive in Norway, many without knowing how old they are or unable to document their age. To ensure that children receive their rights and that adults are not treated as children, it is necessary to assign a chronological age for these individuals. Evaluation of skeletal maturation of the hand and tooth development has been used for age assessment of asylum seekers in Norway in cases of doubt. These methods have been criticized for their lack of precision, but currently no better methods have been suggested.

In 2016, the Norwegian Institute of Public Health was assigned a national professional responsibility to evaluate and improve the methods used for medical age estimation (from 1.1. 2017 transferred with the Department of Forensic Sciences to Oslo University Hospital). Department of Forensic Sciences has, in cooperation with the Knowledge Centre for the Health Services, conducted a systematic examination of the scientific evidence on several of the medical age estimation methods.

The objective of this systematic review is to assess the scientific evidence on the agreement between chronological age and bone age based on the maturation stages of the Greulich and Pyle atlas (GP skeletal age), and, if possible, to describe any variations between different populations.

Since the Greulich and Pyle atlas is the most widely used method for age estimating based on x-ray of the hand, we chose to focus on this system. In parallel, we have also conducted a systematic review of age estimation using Demirjians development stages on wisdom teeth.

Method

We searched for studies in the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase and Google Scholar. Our search date was May 2016. The literature search covered studies that use x-ray of the teeth or hand, and CT or MRI of the clavicle, knee and ankle for age estimation of children and adolescents between 10 and 25 years. The search for studies that used the Greulich and Pyle atlas was updated in January 2017. Two people independently read title and summary for 10640 references. Of these, we found 658 potentially relevant publications for age estimation using x-ray of the hand. Two people independently considered these studies in full text. We included 17 studies with results that present age estimation based on the Greulich & Pyle atlas. We included two different approaches to present the data (in this report referred to as approach A and B). Both approaches require a known chronological age and an observed skeletal age:

A) is based on the chronological age and presents the average difference between chronological age and GP skeletal age based on the maturation stages of the Greulich and Pyle atlas for separate age groups (ages not combined in more than annual increments).

B) is based on the GP skeletal age and presents the average chronological age from GP skeletal age in the Greulich and Pyle atlas.

Two people independently assessed risk of bias in the included studies by the QUADAS-2 checklist to assess the quality of diagnostic accuracy studies.

Results

We found 17 studies that compared chronological age with skeletal age based on hand x-ray and the GP atlas. The studies included from 68 to 2614 persons with known chronological age. All but one study included both boys and girls. Three studies were from Turkey, four studies from India, and one study each from Canada, China, France, Iran, Italy, the Netherlands, Pakistan, Spain, Taiwan, and the United States respectively. We considered that the majority of studies had either low or unclear risk of bias based on the QUADAS-2 assessments. The exception was results from the studies with approach B, where three of four studies had a high risk of a particular form of selection bias called "age mimicry".

The majority of studies present results as the average difference between chronological age and GP skeletal age within age groups (approach A). The analysis shows that the variation between studies was greater than expected by chance, even though the variations between studies from different parts of the world were moderate. The difference between GP skeletal age and chronological age rarely exceeded one year for the average of a group in single studies.

Four studies, including two that we analyzed based on the authors' original data, present results as average chronological age within maturation stages from the Greulich and Pyle atlas (approach B). We found that results from three of these studies were influenced by the age composition of the included study population. This bias has previously been described as "age mimicry", which means that the average age observed in each development stage is affected by the included age range and number of participants in each age group. Only one of the four studies with results using approach B had a large study population with a relatively even distribution in age groups: Chaumoitre 2016. This study of a multi-ethnic population in Marseille (France), found that the difference between GP skeletal age from the atlas (maturation stages) was on average never greater than 0.5 years from chronological age. Chaumoitre 2016 gives an appropriate estimate of the variation in age for this population if the atlas is to be used for estimation of chronological age. The width of 95% prediction intervals for boys aged 10 to 19 years ranged from 4.0 years to 5.9 years.

Discussion

We included studies with two different analytical approaches (approach A and B). Most studies presented the average difference between chronological age and GP skeletal age for separate age groups based on age cohorts (approach A). This approach provides overall results for GP skeletal age for a group of individuals within an age cohort (for example, all boys who are 14 years), and reflects that the original use of the Greulich and Pyle atlas was to describe normal skeletal maturation. We have summarized these studies, and found that on average there is a relatively strong association between GP skeletal age and chronological age on a group level, although certain ages in individual studies can have an average difference of more than one year. These studies show that the GP atlas, which is based on radiographs taken of children in the 1930s, still describes normal skeletal development relatively well in different populations studied the last 10-15 years. However, standard deviations from studies presented as approach A cannot be used to estimate predict intervals if the GP atlas is used for estimation of chronological age (which is a "reverse" scenario).

Studies on how chronological age is distributed from GP skeletal age (approach B) are most appropriate to illustrate the uncertainty of the GP atlas when it is used for age estimation. However, these studies must have a study population with an even age distribution, and ensure that the lower and upper age limits are appropriate. For the results to be as correct as possible, the study population must be sufficiently large, have roughly the same number of individuals in each age group and cover the entire expected age range for the stages one aims to examine. Otherwise, the study will be affected by the phenomenon age mimicry and the results will be unreliable. We considered that only one study had a sufficiently good study design to describe appropriately how chronological age is distributed from skeletal age: Chaumoitre 2016.

More studies similar to this example are needed to evaluate the method's ability to predict age in different populations. An alternative solution is to assemble primary data sets on chronological age and development stage for individuals. Such data will make it possible to use statistical models in order to minimize the effect of age mimicry even in datasets with an uneven age distribution.

Conclusion

We have summarized studies presenting GP skeletal age from known chronological age, and found that there is good agreement between the average values of GP skeletal age and chronological age, although certain age groups in individual studies may have an average difference of about one year. These studies cannot be used to estimate prediction intervals if the GP atlas is used for age estimation.

The studies showing how chronological age is distributed from GP skeletal ages (maturation stages) are most appropriate to illustrate the uncertainty of the GP atlas when it is used for age estimation. We found only one study with approach B that had a reliable study design: Chaumoitre 2016. This study showed that for the included population, 95% prediction intervals vary from 4 years to 5.9 years for boys between 10 and 19 years. This illustrates the uncertainty of the method when it is used on a given population to estimate age.

To explore the uncertainty of the Greulich and Pyle atlas for age estimation in other populations, more studies with the design of Chaumoitre 2016 is needed. An alternative solution is to assemble primary data sets of chronological age and development stage for individuals, and apply statistical models to minimize the effect of age mimicry.