Comprehensive developments in deaf children aged 6 months to 6 years

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Research article

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Comprehensive developments in deaf children aged 6 months to 6 years

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Abstract

Background. In the early stages of life, auditory input and communication are essential for acquisition of speech, cognition, behavior and social development. While so far the development evaluation of deaf children has not been given much attention. This study was design to evaluate the comprehensive developments of young children with severe or profound hearing loss and explore the effect of age on developments.

Methods. 500 children with severe or profound hearing loss (287 boys, 26.00±18.89 months, range 6-72 months) were recruited in this study. The developments of children were assessed by Gesell development schedules. All the children were divided into three groups according to age: infancy (6-12months), toddler (12-36months) and preschool (36-72months). Developments were evaluated and compared among the different age group.

Results: Compared with the normal developmental criteria, deaf children had overall development delay and only 50 (10%) reached the normal developmental level. The delay occurred in full-dimensional developments including gross motor, fine motor, adaptability, language, and social skill, the normal developmental rates of which were 42.0%, 24.8%, 27.4%, 4.2%, and 14.0%, respectively. For the five aspects developments, Pearson's correlation showed that they were statistically significant correlated with each other (all p<0.001). Then, the developments among the different age group were compared and found that developments got worse with age (p<0.001). Apart from age, the results of multiple regression reveled that behavior audiology with hearing aids was negative correlated with the developments (p<0.05).

Conclusions. Deaf children could have overall developmental delay. Language

development was the worst, followed by social skills and adaptability, and gross motor development, followed by fine motor, was the best. The older the deaf children, the more obvious the lag behind of development.

Keywords: young; children; deaf; comprehensive development; early.
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Background

Hearing loss was one of the most prevalent chronic conditions in children and brought serious health implications and stressor for the patient and their families [1, 2]. The harm and stress not only came from hearing loss itself, but also from the developmental problems that hearing loss induced. Whereas a great deal of researches has been devoted to understanding spoken language development in deaf children, comparably less research has been focused on nonverbal functions. Actually, children with hearing loss were likely to present with delays in non-verbal development such as balance and motor development[3-5]. Therefore, it became crucial to evaluate the comprehensive development of deaf children.

The evaluation tools in previous works on the developments of deaf children were various but with some shortcoming: lack of objectivity and imitated to one aspect of development[5, 6]. Therefore, the comprehensive and authoritative methods were favorable. The Gesell developmental schedules was a comprehensive multi-dimensional assessment system monitoring growth of young child[7], which has been used to assess intelligence of infant with other disease [8, 9]. Until to now, for the children with hearing impairment, little study has used it[10].

The children with severe or profound hearing loss, such a vulnerable group, deserved our special attention. Moreover, previous research reported that developmental level of deaf children before cochlear implantation (CI) was correlated with postoperative rehabilitation effect[10, 11]. Thus, for children with severe or profound hearing loss, who were most likely candidates for CI, evaluation of preoperative developments was of necessity. Unfortunately, so far little was known about the comprehensive developments of deaf children and assessment of development of these children were not included yet in the clinical program [10, 12]. Hence, in this study, we retrospectively collected the preoperative results of Gesell developmental schedules of deaf children.

Methods

Participants

645 children diagnosed with bilateral severe or profound sensorineural hearing loss in the department of Otorhinolaryngology-Head and Neck Surgery, Beijing Children's Hospital, Capital Medical University between October 2012 and December 2019 were recruited in this study. Children were included in this retrospective study if they had: 1) confirmed bilateral severe or profound sensorineural hearing loss; 2) received completed auditory evaluation; 3) received formal Gesell development evaluations; 4) received computed tomography (CT); 5) all the tests were evaluated before cochlear implantation, and 6) no evidence of major secondary disabilities such as white matter diseases, nervous system disease, physical disability. The following data, such as gender, age, large vestibular aqueduct syndrome (LVAS) diagnosed by CT, were collected by medical history questionnaire. Table 1 summarizes the demographic characteristics of the sample. This study was approved by the Institutional Review Board of Beijing Children's Hospital, Capital Medical University.

Auditory Evaluation

Comprehensive audiological evaluations were performed by trained professional staffs in our audiotory center. Behavior audiometry was obtained with TDH-39P earphones (Interacoustics, AD229e) for the frequencies 250 through 8000 Hz with the maximum output of 120dB HL in the frequency of 500-4000Hz and 110dB HL in the frequency of 250 and 8000Hz bilaterally. The children also received aided behavior audiometry by trained physicians. Auditory steady-state response (ASSR) was obtained with TDH-39P earphones (Interacoustics, Eclipse) for the frequencies 500 through 4000 Hz with the maximum output of 100dB nHL bilaterally. Better ear hearing threshold was calculated for the thresholds of 500, 1000, 2000, and 4000Hz, with a value of 5dB over the limit at the frequency used as the calculation for no response thresholds[13]. The difference between binaural hearing was calculated by the results of ASSR. If the difference between binaural hearing was $\leqslant$10 dB nHL, we defined it symmetry of binaural hearing; if it was > 10 dB nHL, we thought it asymmetry[14].

Gesell development schedule evaluation

Certified clinical care physicians with expertise in working with deaf children administered developmental assessments to the study participants. The physicians selected the most appropriate test item of the Gesell development schedule for the child depending on their ages. The Gesell Developmental Schedule was a set of developmental metrics of young children developed by Dr. Arnold Gesell and his colleague, which could be used to evaluate the child's intelligent development[15]. It has been adopted and used in China for many years, which contained five subscales: gross motor, fine motor, adaptability, language and social skill [7]. The Gesell Development Schedule operated off what was known as an individual's developmental quotient (DQ), which was evaluated by ascertaining whether or not the children were displaying the appropriate behavior for the age: DQ = (development age / chronological age) *100[7]. According to the developmental quotient classification, that normal was DQ$\geqslant$86, suspicious was DQ$\geqslant$76 and$\leqslant$85, mild neurological damage was DQ$\geqslant$55 and$\leqslant$75, and moderate and sever neurological damage was DQ$\leqslant$54 were adopted in our study[7, 10].

Statistical analysis

The statistical analyses were performed using SPSS for Windows, version 22 (SPSS Inc, Chicago, IL, USA). Continuous variables were expressed as the mean ± SD and categorical values were shown in the form of frequencies. For continuous variables, T-test or ANOVA were used for normally distributed data or Mann–Whitney U test for non-normally distributed data. For categorical variables, chi square test was used. Correlations between the different developments were analyzed by Pearson's correlations. Multivariate linear regression was performed to assess the relative contributions of corresponding variables to Gesell developments. p value of <0.05 was considered statistically significant.

Results

Finally, participants in this study were composed of 500 children (boys, 57.4%) with a mean age of 26.00±18.89 months (range 6-72 months) (Table1). 77(15.40%) children were diagnosed with LVAS. The audio logical evaluations include ASSR, behavior audiometry and behavior audiometry with hearing aids, the results of which were in Table 1. By calculating the difference between binaural hearing, more than half (60.60%) of patients had symmetric binaural hearing.

Compared with the normal developmental criteria of 85 score, deaf children had overall development delay and only 50 (10%) reached the normal developmental level. The delay occurred in full-dimensional developments including gross motor, fine motor, adaptability, language, and social skill, the normal developmental rates of which were 42.0%, 24.8%, 27.4%, 4.2%, and 14.0%, respectively. According to the results, we could found the language development was the worst, followed by social skills, adaptability, and fine motor, whereas gross motor was the best (Table 1). We further analyzed the relationship between the five subdomains' development, and the results of Pearson's correlation showed that they were closely related to each other (all p<0.001) (Table 2).

In order to explore the effect of age on the development of deaf children, deaf subjects were divided into three groups: infancy(6-12months), toddler (12-36months) and preschool(36-72months). Subject demographics of these three groups were provided in Table3. There was no significant difference in gender (p=0.057) and results of auditory evaluation (all p>0.05). whereas, in LVAS, the difference between binaural hearing and the symmetry of hearing, there was significant difference among the three age groups. However, Subsequent multivariate linear regression analysis showed that the above three factors had no effect on developments (Table 5). Thus the basic demographic characteristics among the three age group could be thought consistent and then the developments of different age group were compared.

Compared among the three age groups, the developments in the infancy was the best, followed by toddler, and the developments in the preschool group was the worst. The same results were found in all the sub-dimensional developments (Table 3 and Fig.1). In the toddler group, the language development was lag behind far away, whereas the other developments were almost near the normal developmental level. Until to toddler group, the other developments were lagging behind. However, no matter in which age group, language development still was the worst and the gross motor was the best (Table 3 and Fig.1). From Table4, we could find that the developmental level tended to severer neurological damage with older children.

Afterwards, taking all the potential confounders into consideration, the related factors for developments were analyzed using the multivariate linear regression analysis. Apart age had negative effects on developments (all $p<0.001$), the aided behavior audiometry had effect on Gesell developments ($\beta=-0.101$, $p<0.05$) including gross motor ($\beta=-0.035$, $p<0.01$), language ($\beta=-0.197$, $p<0.01$) and social skill ($\beta=-0.132$, $p<0.05$). The gender, LVAS, ASSR, symmetry of hearing had no effects on developments (all $p>0.05$) (Table 5).

Discussion

To the best of our knowledge, this was one of the largest scale studies evaluating comprehensive developments of hearing-impaired children. Unlike previous studies only evaluating one certain aspect of development[16], the evaluation about comprehensive developments to hearing-impaired children were promoted in our study. The subjects in our study were the children with severe or profound hearing loss, namely deaf children, which was a special group who were candidatures for CI. As previous research has observed that preoperative developmental level was correlated with postoperative rehabilitation effects[10], thus the developments of deaf children before CI should be evaluated. Lastly, these deaf children in our study were aged between 6 years and 6 years, which was not only the critical period of language, motor-skill, and cognition developments, but also the favorable period of intervention and rehabilitation, so to evaluate the developments in the critical time was of great necessity.

Our study showed developmental delay in deaf children. Of the 500 patients, only 10% children reached normal development criteria, which suggested that certain attention should be paid to the developments of deaf children. According our finding, the delay not only occurred in oral development but also in non-verbal developments including motor, adaptability, and social skill. The poor oral or motor developments bounded to affect children to contact with the external world: for perception, action, academic skills, and acquisition of other skills. Consistent with our results, Soylemez described delays in balance, and motor development of children with sensorineural hearing loss[17]. Masuda postulated that concurrent damage to the vestibular structures and sensory organization deficit was the primary cause of motor skills and balance deficits in hearing-impaired children[17]. Wong found childhood deafness caused psycho-intellectual, mood disorders and social developmental disorders due to difficulty in contacting with the surroundings[18, 19].

It's well known that, in the early stages of life, auditory input and communication were essential for acquisition of speech. In our study, language development was the worst of the five aspects developments. Moreover, in the first year of life, language was lag behind far away from the normal children, whereas, the other developments, such as motor developments, adaptability, and social skill, were nearly close to the normal developmental standards. Until to the toddler stage, the non-verbal developments were lagging behind. Actually, in typically developing children, motor and language milestones are closely coupled and tend to occur in synchrony[20].Accordingly, we speculated that auditory deprivation occurring early might firstly impact hearing-related effects such as language and then had secondary cognitive and motor skill, which is coordinated with Conway's view[21].

It should be mention that, of the five aspects developments, motor developmental level was the best, no matter in the infancy period or the older stage. From this, we might speculate that the effects of hearing deprivation on motor are limited compared to other aspects. In our study, the development of gross motor was better than that of fine motor. The reason might be that learning of new complex or fine movements need verbal aids and rectify[22]. Apart from the inconsistency, David found a disassociation between fine and gross motor development in deaf children: fine motor skills was weakly negative correlated with age, whereas gross motor skills had the contrast correlation[23]. Because of only 22 children in his study, the conclusion need explored. In addition, Horn found that fine, but not gross, motor abilities were strongly correlated with expressive and receptive language abilities[11], which indicating that the close coupling between the fine motor skills and language developments.

What causes deaf children with developmental delay? The current prevailing doctrine were: auditory deprivation, delays in spoken language development, and underlying co-cause of deafness[21]. Although previous work suggested there may be close links between nonverbal cognitive abilities and language development[24],our analysis only could show the five aspects developments were interacted with each other without causal relationship.

The other major finding of this paper was that the older the child, the more obvious the lag behind of developments, which indicated the importance of early identification and early intervention. In our opinion, firstly, the identification and intervention of hearing loss should be early. Newborn hearing screening were once stressed[25]. Fulcher underlined that if children with severe or extreme hearing loss could be diagnosed at an early stage, used amplification for up to three months, received auditory-verbal training up to 6 months and a cochlear implant was inserted for up to

18 months and they could catch up with their normally hearing peers at age of three [26]. Secondly, the identification and intervention of developments in deaf children also should be early [3, 27]. As a matter of fact, intervention was efficient. Jackson found that the performance could be prominent progress after 6 months training[28]. Meinzen revealed that children enrolled prior to 6 months were more likely to have age-appropriate language skills [29]. In addition, it was proposed that preoperative developments were associated with improvement in auditory perception and speech production after CI in children[10, 11]. Thus, the identification and intervention of preoperative developments were of significance.

Apart from age, Aided behavior audiometry were negative correlated with the developments in our study. In our opinion, the aided behavior audiometry potentially represented the ability to perceive sounds and to some extent could predict the effect of the intervention, which were rarely mentioned in other studies. Certainly, in addition to the factors we mentioned above, a variety of possible causes for developmental deficits has been explored including: hearing device, age at hearing aids, the etiology of deaf, parental behaviors such as overprotection, and so on[30-33].

Potential limitations of the current study should be considered. First, this was only a cross-sectional study, and a causal relationship could not be concluded. Second, the overall effect of the factors in our study was not enough and other factors such as hearing device, age at hearing aids and genetic status should be collected. Third, longitudinal data was needed to verify the above conclusions.

Conclusion

In conclusion, this study provides evidence that deaf children could have overall developmental delay. Language development was the worst, followed by social skills and adaptability, and gross motor development, followed by fine motor, was the best. The older the deaf children, the more obvious the lag behind of development. According to our finding, we proposed that comprehensive care need paid to hearing impaired children. Early intervention and improvement of hearing loss allows of no delay, meanwhile early diagnosis and intervention of comprehensive developments could promote better rehabilitation for deaf children.

Abbreviations

CI, cochlear implantation; CT, computed tomography; LVAS, large vestibular aqueduct syndrome; ASSR, Auditory steady-state response; DQ, developmental quotient;

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Availability of data and materials

The datasets generated during and/or analyzed during the current study were available from the corresponding author on reasonable request.

Authors' contributions

All authors participated in the design of the study. Xin Ni, Jie Zhang, and Yanhong Li managed and coordinated the study and the project. Yang Yang, Bing Liu, Wanxia Zhang, Yi Zhou, Min Chen, and Wei Liu recruited the patients and performed the evaluation. Bei Li, Shanshan Liu, Xiaoxu Wang, Shilan Li collected the data. Yanhong Li draft the manuscript and Jie Zhang gave the efficient guidance for the article. All authors read and approved the final manuscript.

Competing interests

The authors declared that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Beijing Children's Hospital, Capital Medical University with a waiver of informed consent.

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References

1. Korver AM, Smith RJ, Van Camp G, Schleiss MR, Bitner-Glindzicz MA, Lustig LR, Usami SI, Boudewyns AN: Congenital hearing loss. Nat Rev Dis Primers 2017, 3:16094.
2. Quittner AL, Barker DH, Cruz I, Snell C, Grimley ME, Botteri M, Team CDI: Parenting Stress Among Parents of Deaf and Hearing Children: Associations with Language Delays and Behavior Problems. Parenting-Science and Practice 2010, 10(2):136-155.
3. Kimura Y, Masuda T, Kaga K: Vestibular Function and Gross Motor Development in 195 Children With Congenital Hearing Loss-Assessment of Inner Ear Malformations. Otol Neurotol 2018, 39(2):196-205.
4. Emmett SD, Francis HW: Bilateral hearing loss is associated with decreased nonverbal intelligence in US children aged 6 to 16 years. Laryngoscope 2014, 124(9):2176-2181.
5. Phillips J, Wiley S, Barnard H, Meinzen-Derr J: Comparison of two nonverbal intelligence tests among children who are deaf or hard-of-hearing. Research in developmental disabilities 2014, 35(2):463-471.
6. Chen M, Wang Z, Zhang Z, Li X, Wu W, Xie D, Xiao ZA: Intelligence development of pre-lingual deaf children with unilateral cochlear implantation. International journal of pediatric otorhinolaryngology 2016, 90:264-269.
7. Gesell A: Monthly increments of development in infancy. Journal of Genetic Psychology 1925, 32:203-208.
8. Marques RC, Dórea JG, Bernardi JVE, Bastos WR, Neurol OMJ-CB: Prenatal and postnatal mercury exposure, breastfeeding and neurodevelopment during the first 5 years. COGNITIVE AND BEHAVIORAL NEUROLOGY 2009, 22(2):134-141.
9. Sun Q, Chen YL, Yu ZB, Han SP, Dong XY, Qiu YF, Sha L, Guo XR: Long-term consequences of the early treatment of children with congenital hypothyroidism detected by neonatal screening in Nanjing, China: a 12-year follow-up study. JOURNAL OF TROPICAL PEDIATRICS 2012, 58(1):79-80.
10. Yang Y, Haihong L, Jun Z, Min C, Ying L, Jinsheng H, Wei L, Jie Z, Xin N: The value of Gesell score in predicting the outcome of cochlear implantation in children. Eur Arch

Otorhinolaryngol 2017, 274(7):2757-2763.

11. Horn D, Davis B, Pisoni D, Miyamotor R: Development of visual attention skills in prelingually deaf children who use cochlear implants. EAR AND HEARING 2005, 26(4):389-408.
12. Meinzen-Derr J, Wiley S, Phillips J, Altaye M, Choo DI: The utility of early developmental assessments on understanding later nonverbal IQ in children who are deaf or hard of hearing. International journal of pediatric otorhinolaryngology 2017, 92:136-142.
13. Brown RF, Hullar TE, Cadieux JH, Chole RA: Residual hearing preservation after pediatric cochlear implantation. Otol Neurotol 2010, 31(8):1221-1226.
14. Seong J, Yang SK, Pilkeun Jang P, Lee SY, Carandang M, Choi BY: Clinical Factors Influencing the Trial and Purchase of Bilateral Microphones with Contralateral Routing of Signal in Patients with Asymmetric Sensorineural Hearing Loss. JOURNAL OF AUDIOLOGY AND OTOLOGY 2020, 24(1):29-34.
15. Marques RC, Dórea JG, Bernardi JVE, Bastos WR, Neurol OMJ-CB: - Prenatal and postnatal mercury exposure, breastfeeding and neurodevelopment during the first 5 years, vol. 22; 2009.
16. Bigler D, Burke K, Laureano N, Alfonso K, Jacobs J, Bush ML: Assessment and Treatment of Behavioral Disorders in Children with Hearing Loss: A Systematic Review. Otolaryngol Head Neck Surg 2019, 160(1):36-48.
17. Soylemez E, Ertugrul S, Dogan E: Assessment of balance skills and falling risk in children with congenital bilateral profound sensorineural hearing loss. International journal of pediatric otorhinolaryngology 2019, 116:75-78.
18. Wong CL, Ching TY, Leigh G, Cupples L, Button L, Marnane V, Whitfield J, Gunnourie M, Martin L: Psychosocial development of 5-year-old children with hearing loss: Risks and protective factors. International journal of audiology 2018, 57(sup2):S81-s92.
19. Wong CL, Ching TYC, Cupples L, Button L, Leigh G, Marnane V, Whitfield J, Gunnourie M, Martin L: Psychosocial Development in 5-Year-Old Children With Hearing Loss Using Hearing Aids or Cochlear Implants. Trends in hearing 2017, 21:2331216517710373.
20. Michaelis R, Haas G: Milestones in early childhood development--decision-making aids for clinical practice. Das Offentliche Gesundheitswesen 1990, 52(8-9):486-490.
21. Conway CM, Karpicke J, Anaya EM, Henning SC, Kronenberger WG, Pisoni DB: Nonverbal cognition in deaf children following cochlear implantation: motor sequencing disturbances mediate language delays. Developmental neuropsychology 2011, 36(2):237-254.
22. Wiegersma PH, Velde AV: Motor development of deaf-children. JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY AND ALLIED DISCIPLINES 1983, 24(1):103-111.
23. Horn DL, Pisoni DB, Miyamoto RT: Divergence of fine and gross motor skills in prelingually deaf children: implications for cochlear implantation. Laryngoscope 2006, 116(8):1500-1506.
24. Oliver. B, Dale. PS, Plomin R: Verbal and nonverbal predictors of early language problems: an analysis of twins in early childhood back to infancy. Journal of child language 2004, 31(3): 609-631.
25. Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. Pediatrics 2007, 120(4):898-921.

26. Fulcher A, Purcell A, Baker E, Munro N: Listen up: children with early identified hearing loss achieve age-appropriate speech/language outcomes by 3 years-of-age. INTERNATIONAL JOURNAL OF PEDIATRIC OTORHINOLARYNGOLOGY 2012, 76(12):1785-1794.
27. Fellinger MJ, Holzinger D, Aigner M, Beitel C, Fellinger J: Motor performance and correlates of mental health in children who are deaf or hard of hearing. Developmental medicine and child neurology 2015, 57(10):942-947.
28. Jackson CW, Schatschneider C: Rate of language growth in children with hearing loss in an auditory-verbal early intervention program. American annals of the deaf 2014, 158(5):539-554.
29. Meinzen-Derr J, Wiley S, Choo DI: Impact of early intervention on expressive and receptive language development among young children with permanent hearing loss. American annals of the deaf 2011, 155(5):580-591.
30. Gheysen F, Loots G, Van Waelvelde H: Motor development of deaf children with and without cochlear implants. Journal of deaf studies and deaf education 2008, 13(2):215-224.
31. Leigh G, Ching TY, Crowe K, Cupples L, Marnane V, Seeto M: Factors Affecting Psychosocial and Motor Development in 3-Year-Old Children Who Are Deaf or Hard of Hearing. Journal of deaf studies and deaf education 2015, 20(4):331-342.
32. Ruben RJ: Language development in the pediatric cochlear implant patient. Laryngoscope Investig Otolaryngol 2018, 3(3):209-213.
33. Janky KL, Thomas MLA, High RR, Schmid KK, Ogun OA: Predictive Factors for Vestibular Loss in Children With Hearing Loss. American journal of audiology 2018, 27(1):137-146.

Figures

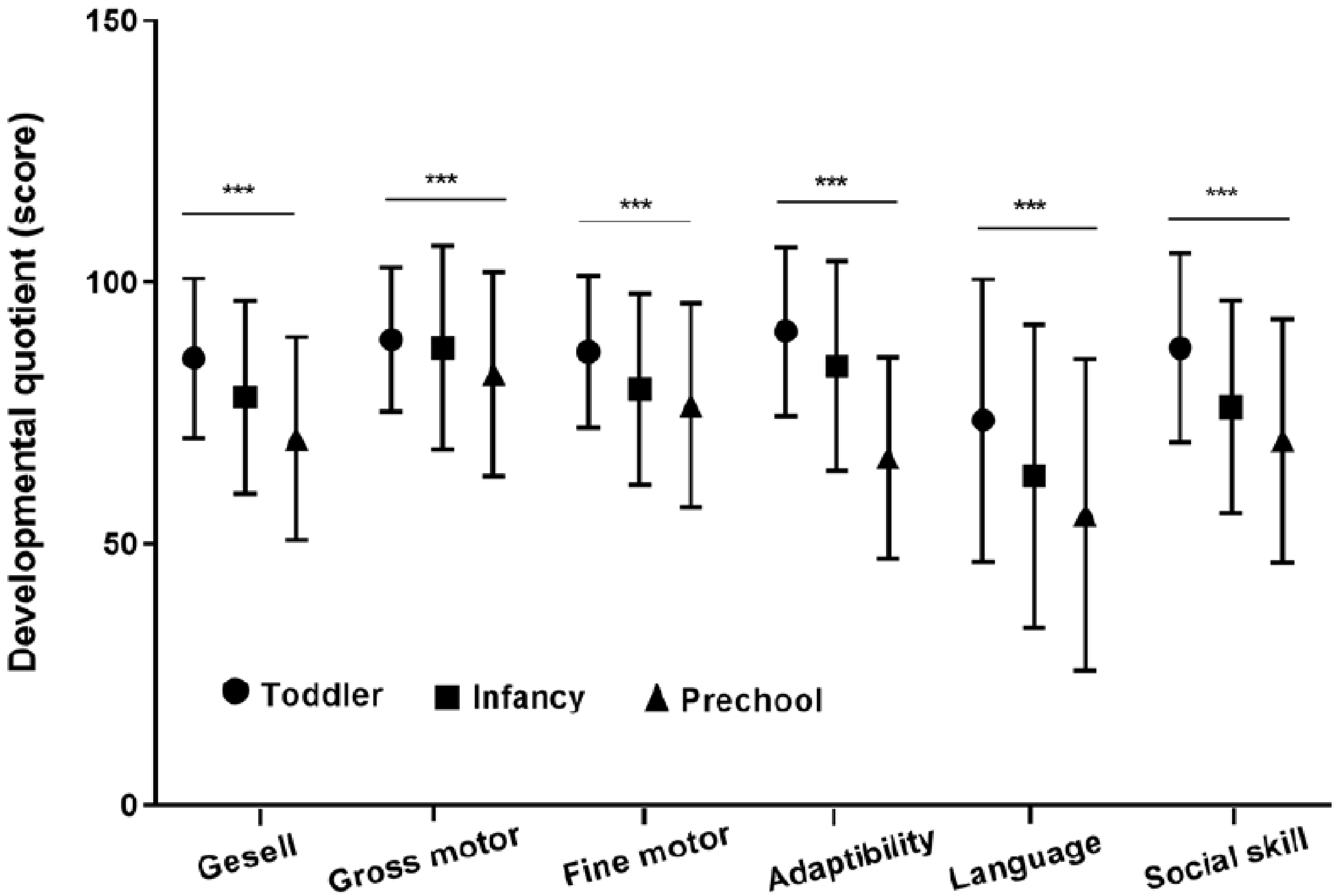

Figure 1

Comparison of developments of children with hearing loss among toddler, infancy and preschool group. Data were presented as mean ± SD. There was significant difference among the three groups (ANOVA, all $p<0.001$). In addition, there was significant difference between any two groups (T-test, all $p<0.05$).

Supplementary Files

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