IMMITTANCE IN INFANTS 0 – 12 MONTHS:
MEASUREMENTS USING A 1000 Hz PROBE TONE

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Dedicated to my loving parents -

Who always encouraged me to aim higher…
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Rapid implementation of universal newborn hearing screening programs has exposed a need for a reliable test of middle ear function for timely identification of middle ear pathology and for differentiation between true sensorineural and conductive hearing losses. Use of higher probe tone frequencies for the assessment of immitance measures have proven to be more reliable and accurate in identifying MEE in infants. However a lack of classification-guidelines and age specific normative data exists. This study investigated the characteristics and normative values of high frequency tympanometric and acoustic reflex results for infants (n = 936 ears). Participants were 510 infants (262 male, 248 female) aged 0 – 12 months (mean age = 12.8 weeks) recruited from primary health care and immunization clinics in a South African community. A three-part procedure was performed on each test ear: 1) OAEs were recorded and pass results served as control variable for normal middle ear functioning; 2) 1000 Hz probe tone admittance, susceptance and conductance tympanograms were recorded and analysed in terms of shape, tympanometric peak pressure and maximum (peak) admittance; 3) 1000 Hz probe tone acoustic reflexes, measured with a 1000 Hz ipsilateral stimulus, were recorded and thresholds determined. Significant associations were observed between tympanogram shape, and OAE pass or fail results. 93% of ears with an OAE pass result displayed peaked tympanograms, while 79% of ears with absent OAE’s displayed flat tympanograms. Single peaked tympanograms were recorded in 782 ears (84%), double peaked tympanograms in 41 (4%) ears and flat sloping tympanograms in 112 (12%) ears. Admittance ($Y_a$) tympanograms for the total sample displayed a mean admittance value of 2.9 mmho, with a standard deviation of 1.1 mmho. The 90th percent range was determined at 1.5 mmho (5th percentile) to 4.9 mmho (95th percentile). Mean tympanometric peak pressure in $Y_a$ tympanograms was 0.1 daPa, with a standard deviation of 61 daPa. The 90th percent range was -110 daPa to 90 daPa for the 5th and 95th percentiles respectively. Gender specific norms indicated a higher admittance for male ears. Age specific norms indicate a gradual increase in admittance indicating the need for age specific normative classification systems. Ipsilateral 1000 Hz stimuli acoustic reflex measurement proved successful with a 1000 Hz stimuli.
probe tone and present reflexes were recorded in 84% of ears tested. Significant association between acoustic reflex presence, OAE pass and peaked tympanogram results were observed. The normative tympanometric values derived from the cohort may serve as a guide for identification of middle ear effusion in neonates. High frequency tympanometry in combination with acoustic reflexes proves a useful measure for verifying middle ear functioning in young infants.

**Key words:** acoustic reflex, admittance, conductance, high frequency probe tone, immittance, middle ear effusion, neonatal hearing screening, peak admittance, susceptance, tympanometric peak pressure, tympanometry
DIE IMPLEMENTERING VAN UNIVERSELE NEONATALE GEHOORTOETSENDING HET 'N BEOEFTE ONTHUL AAN 'N BETROUBARE TOETS VIR MIDDELDOOR FUNKSIONERING VIR DIE TYDIGE IDENTIFIKASIE VAN MIDDELDOOR PATOLOGIE, EN OM SENSORIES-NEURALE EN KONDUKTIEWE GEHOORVERLISE TE KAN ONDERSKEI. DIE GEBRUIK VAN 'N HOËR FREKWENSIE MEETTOON IS AS MEER BETROUBAAR EN AKKURAAT BEWYS. 'N GEbrek AAN Klassifikasie-Riglyne en ouderdom-spesifiek normatiewe waardees bestaan egter tans. Hierdie studie het die eienskappe en normatiewe waardees van hoë frekwensie timpanometrie en akoestiese refleks resultate vir kinders (n = 936 ore) wat OAE toetsing geslaag het, beskryf. Deelnemers was 510 kinders (262 manlik, 248 vroulik) tussen die ouderdom van 0 – 12 maande (gemiddeld = 12.8 weke) wat gewerf is vanaf 6-week primêre gesondheidsorg en immuniserings klinieke in 'n Suid-Afrikaanse gemeenskap. 'N Dreivoudige prosedure is op elke van die deelnemers se ore uitgevoer: 1) OAE toetsing is uitgeoer en 'n slaag resultaat het gedien as kontrole vir normale middeloorfunksionering; 2) 1000 Hz meettoon admittansie-, suskeptansie- en konduktansie timpanogramme is opgeneem en geanaliseer na aanleiding van vorm, piek timpanometriese druk en maksimum (piek) admittansie; 3) 1000 Hz meettoon akoestiese refleks toetsing is uitgeoer met 'n 1000 Hz ipsilaterale stimulus en drempels is vasgestel. Betekenisvolle assosiasies is waargeneem tussen timpanogram vorm en OAE slaag of verwys resultate. 93% van ore met OAE slaag resultate het timpanogramme met duidelike pieke getoon, terwyl 79% wat ore met OAE verwys resultate plat timpanogramme vertoon het. Enkel-piek timpanogramme is in 782 (84%) van ore waargeneem, dubbelpiek timpanogramme in 41 (4%) van ore en plat timpanogramme in 112 (12%) ore. Admittansie (Y\text{a}) timpanogramme vir die totale groep het 'n gemiddelde admittansie waarde van 2.9 mmho, met 'n standaard afwyking van 1.1 mmho getoon. Die 90 % omvang was waargeneem tussen 1.5 mmho (5de persentiel) en 4.9 mmho (95ste persentiel). Gemiddelde timpanometriese piek druk in Y\text{a} timpanogramme was 0.1 daPa, met 'n standaard afwyking van 61 daPa. Die 90 % omvang was -110 daPa tot 90 daPa vir die 5de en 95ste persentiel afsonderlik. Geslag-spesifieke norme het 'n hoër gemiddelde admittansie waarde vir manlike ore getoon. Ouderdom-spesifieke norme dui op 'n geleidelike verhoging in admittansie wat
die behoefte aan ouderdom-spesifieke normatiewe klassifikasie-sisteme bevestig. Ipsilaterale 1000 Hz stimulus akoestiese refleks metings het getoon dat reflekse suksesvol waargeneem word wanneer 'n 1000 Hz meettoon aangewend word. Reflekse is waargeneem in 84% van die toetsore. Betekenisvolle assosiasies tussen die teenwoordigheid van 'n akoestiese refleks, OAE slaag resultaat en duidelik gepiekde timpanogramme is aangedui. Die normatie waardes kan dien as 'n riglyn vir die identifkasie van middeloor effusie in kinders. Hoë frekwensie timpanometrie tesame met akoestiese reflekse blyk 'n waardevolle metode vir evaluering van middeloor funksionering in jong kinders te wees.

**Sleutel terme:** admittansie, akoestiese refleks, hoë frekwensie meettoon, immittansie, konduktansie, middeloor effusie, neonatale gehoortoetsing, piek admittansie, suskeptansie, timpanometriese piek druk, timpanometrie