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Faculteit Geneeskunde en Levenswetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Correlation between motor and language skills at extremely poor and reference children in Ethiopia

Laura Maes

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij neurologische aandoeningen

PROMOTOR :
Prof. dr. Marita GRANITZER

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De heer Berhanu Nigussie WORKU

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First and foremost, I would like to thank my promoter and co-promoter: Prof. Dr. Marita Granitzer of University of Hasselt and Drs. Berhanu Nigussie Worku of Jimma University. Without them, the process of conducting my master thesis would not have been possible. I would like to thank Drs. Berhanu Nigussie Worku and Drs. Teklu Gemechu Abessa who were willing to give me their data. My gratitude goes to my parents as well, for their support while writing this master thesis and giving me the opportunity to go to Jimma, Ethiopia.

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Sint-Ambrosiusstraat 16, 3920 Lommel, 12/02/2018 M.L.

Research Context

At the United Nations General Assembly of 2015, the Sustainable Development Goals were established. These are the continuation of the Millennium Development Goals, which are a framework of global mobilization to achieve developmental priorities worldwide. It consists of 17 Sustainable Development Goals with 169 targets [1,2]. The first and most important goal is the elimination of poverty by 2030. This includes target 1.1, the eradication of extreme poverty for all people everywhere [3]. Extreme poverty means living with an income less than $1.90 a day and includes severe deprivation of nutrition, health care, education, information, safe drinking water, sanitation facilities, housing and protection from violence [4]. In 2013, about 767 million people lived in extreme poverty [5]. In particular, children are at risk. They are twice as likely to be affected by extreme poverty as adults. Three hundred and eighty-five million children lived in extreme poverty in 2013, with the highest rates for children up to five years of age [5]. Poverty is the main contributor causing more than 200 million children not to reach their developmental potential at five years of age in developing countries [6,7]. It is important, therefore, to have good insight into the developmental profiles of these children. Unfortunately, this information is still lacking in low income settings [8]. This master thesis, therefore, was conducted to give insight in the development of these children, particularly in their correlation of development of motor and language skills. Such knowledge may contribute in designing early interventions.

The master thesis was framed within the international paediatric rehabilitation research of the Rehabilitation Sciences and Physiotherapy program of the Hasselt University in collaboration with the Jimma University of Ethiopia. It contributes to the 'IUCJU2 project Child health and nutrition' (VLIR-UOS), which is a part of the long-term collaboration between the Jimma University in Ethiopia, the department of PXL-Healthcare, the University of Gent and the Hasselt University. The data belong to the PhD projects of Drs. Berhanu Nigussie Worku (Developmental and growth status of children (6-60 months of age) in extreme poverty in Jimma town of Ethiopia: effects of developmental stimulation) and Drs. Teklu Gemechu Abessa (Effects of play-based family-centred psychomotor/psychosocial stimulation on recovery of severely malnourished children of 6-60 months of age during nutritional rehabilitation in the Jimma Zone of Ethiopia). Promoter and co-promoter are Prof. Dr. Marita

Granitzer (University of Hasselt) and Prof. Dr. Patrick Kolsteren (University of Gent) respectively. The PhD studies were fully financed by the 'IUCJU2 project' (VLIR-UOS).

Data-analysis and writing of the master thesis were accomplished mainly in the clinical setting of Jimma, Ethiopia from the fifth of February until the ninth of March, 2018. Voluntary clinical work was done as well in the 'Missionaries of Charity' and 'Jimma University Hospital' mostly on children in extreme poverty, children who are malnourished and children with developmental and other impairments. Social work was performed to keep street children off the streets. All these activities were executed, to get a better image of the cultural context. This was essential to have sufficient insight in the subject of the master thesis. Since collecting enough data during five weeks in Ethiopia was unrealistic, it was decided to use the data of the research projects of Drs. Berhanu Nigussie Worku and Drs. Teklu Gemechu Abessa. The possibilities with the available data were discussed and the research design was made in conjunction with the promoter. Statistical data-analysis and academic writing were fully executed by the student.

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Abstract

BACKGROUND: globally 385 million children live in extreme poverty and are at risk of not reaching their developmental potential. Insight into their developmental profile is still lacking. Such information is however crucial in designing early interventions.

OBJECTIVES: to get more insight into the correlation between the developmental performances of motor and language skills at extremely poor and reference children in Ethiopia.

PARTICIPANTS: 789 children under six years of age living in extreme poverty (471 non-malnourished and 318 stunted) were matched in age and gender with 789 reference children. All children lived in Jimma, Ethiopia.

MEASUREMENTS: performances on the developmental domains in gross motor, fine motor and language skills were cross-sectionally tested by the Denver II-Jimma. This is an adapted and standardized version of the Denver II test to the socio-cultural context of Ethiopian children, in Jimma.

RESULTS: developmental performances in gross/fine motor and language skills were positively and significantly correlated at both children in extreme poverty and reference children. The correlation between fine motor and language skills was significantly weaker in children in extreme poverty compared to reference children. This was not the case for the correlation between gross motor and language skills. The correlation between gross/fine motor and language skills did not differ between extreme poverty children without malnutrition and which were stunted. Neither did the correlation between gross/fine motor and language skills differ between boys and girls at children in extreme poverty and reference children.

CONCLUSION: early interventions should target mostly fine motor and language skills in both non-malnourished and stunted children in extreme poverty. Longitudinal studies, incorporating additional baseline characteristics, have to be performed in future research.

Furthermore, more attention should be paid at the correlation between fine motor and language skills rather than gross motor skills like sitting and walking.

1. Introduction

The highest counts of children in extreme poverty originate from Sub-Saharan Africa, including Ethiopia. Living in extreme poverty with inadequate nutrition, lack of early stimulation and exposure to stress has long-term consequences (Unicef & World Bank Group, 2016). For instance, it can lead to malnutrition (Endris, Asefa, & Dube, 2017). The 2016 Ethiopian Demographic and Health Survey showed that respectively 38%, 10% and 24% children younger than five years were stunted, wasted and underweight. Stunted children, are two standard deviations too short for their age or chronically malnourished. Wasted children, weigh two standard deviations too less for their height or are acutely malnourished. Underweight children, weigh two standard deviations too less for their age. They can be stunted, wasted or both (Central Statistical Agency-Ethiopia, 2017). Hence children in extreme poverty are at risk not to reach their full potential in development.

In light of early interventions (Grantham-McGregor et al., 2007; Walker et al., 2011), it is important to get better insight into their development (UN, 2015). The goal of this master thesis is therefore to contribute to this insight by investigating the correlation between the developmental performances of motor and language skills in extremely poor and reference children in Ethiopia. Recently it was discovered that children in extreme poverty seem to struggle in particular with language skills among other developmental problems (Worku et al., 2018). Awareness of a possible relationship between motor and language skills, has been brought to attention over the last years (Oudgenoeg-Paz, Volman, & Leseman, 2016). Increasingly more studies confirm that such relation exists in children with a typical and atypical development (Leonard & Hill, 2014).

The rationale behind this relationship can be found in the developmental cascades hypothesis (Libertus & Violi, 2016). This hypothesis states that the attainment of a new motor skill can be a catalyst to the development in other behaviours or skills, particularly language. Motor skills are indeed a good predictor of communication skills at a later age, but this does not apply the other way around (Wang, Lekhal, Aaro, & Schjolberg, 2014). This can be accomplished through new learning opportunities, where children interact with their social environment (Leonard & Hill, 2014; Libertus & Violi, 2016). Mostly relations of language skills to the gross motor skills

sitting and walking were investigated. Yet, other motor skills, like rhythmic arm shaking, can also be related to language (Iverson, 2010).

The attainment of sitting is significantly correlated with productive vocabulary, receptive vocabulary at 10 and 14 months of age and spatial language at 36 months of age (Libertus & Violi, 2016; Oudgenoeg-Paz, Leseman, & Volman, 2015; Oudgenoeg-Paz, Volman, & Leseman, 2012). Independently sitting children, can perform spatial-relational object exploration like containing and stacking (Oudgenoeg-Paz et al., 2015). Sitting without support frees the hands for manual exploration of objects. Communicative gestures, that support language, can be developed as well (Iverson & Goldin-Meadow, 2005). Furthermore, the point-of-view of children changes, and encourages face-to-face exchanges (Libertus & Violi, 2016). At last, independent sitting contributes to language development through progression in vocalization by means of for instance the expanded lung capacity (Iverson, 2010).

Attainment of independent walking predicts receptive and productive vocabulary and spatial language at 36 and 43 months of age (Oudgenoeg-Paz et al., 2015; Oudgenoeg-Paz et al., 2012, 2016; Walle & Campos, 2014). Children who walk independently, have more opportunities to explore their environment and experience more complex spatial relationships, optic flow and proprioceptive information. They are able to move around objects and can share all these experiences with others during joint engagement. The child follows in an attentive way the cues of the parents, but also generates social context to elicit their attention themselves. (Leonard & Hill, 2014; Oudgenoeg-Paz et al., 2012, 2016; Walle, 2016).

Most of the research on the relationship between motor and language skills, has been conducted in developed countries on gross motor skills. Recently, the correlation between motor and language skills of children with severe acute malnutrition has been examined in Ethiopia (Smeets C., 2016). Information on children who live in extreme poverty however, is still lacking. Therefore, the goal of this master thesis is to focus on the correlation of the development between motor and language skills at children living in extreme poverty and reference children. The hypothesis is that the correlation between motor and language skills is weaker in children in extreme poverty compared to reference children.

2. Methods

2.1 Participants

The Jimma zone contains 2.8 million people and the capital town Jimma has approximately 149 166 inhabitants (Central Statistical Agency-Ethiopia, 2017). In total 804 children in extreme poverty were included and matched on age and gender with 819 reference children. They all lived in the Jimma zone, South West Ethiopia. Within the children in extreme poverty, 479 were not malnourished and 325 were stunted.

The inclusion criteria for the children who lived in extreme poverty were children between three and 61 months of age who lived in extreme poverty in Jimma (validated by the Office of Women's and Children's Affairs). Children were excluded if they had observable physical disabilities which hinder the performance on the Denver II-Jimma test or were blind/deaf.

The inclusion criteria for the reference children were: children up to six years of age and belonging to the middle/higher socioeconomic class of Jimma, Ethiopia. These were children, whose parents could afford preschool education fees and thus estimated to develop in an optimal way. Children with potential risks in their development were excluded by using a checklist: prematurity, birth weight <2500 grams, tiny body at birth, caesarean section, birth after more than 24 hours of labour, twins/triplets, chronical disease, disease in the first year of life, visual or hearing impairment, restrictions of mobility, severe maternal disease during pregnancy or children suspected to be malnourished (weight-for-age and MUAC z-scores referred to WHO 2006 child growth standards).

2.2 Design

Measurements of children in extreme poverty and reference children up to six years were taken at one fixed point in time (cross-sectional design) by four trained nurses who were blinded. Using a lottery method all the children were randomly selected from children registered by Jimma town's Woman's and Children Affairs Office. The children in extreme poverty were matched to the reference children by gender and age. The correlation between motor and language skills was compared between children in extreme poverty which were

not malnourished, children in extreme poverty which were stunted and reference children. Ethical approval was obtained from Jimma University, Ethiopia (RPGC/217/2010, dated 03/02/2010 and RPGC/36/2013, dated 13/02/2013) and Hasselt University, Belgium (CME 2010/306). Written and oral consents were obtained from the children's parents. Children were always tested in the presence of caregivers.

2.3 Outcome measures and instruments

Primary outcome measures

The primary outcome measures were the performances of the child on the developmental domains gross motor (GM) skills, fine motor (FM) skills and language (LA) skills. This was measured by the Denver II-Jimma, which is an adapted and standardized version of the Denver II test (Frankenburg, Dodds, Archer, Shapiro, & Bresnick, 1992) for children under six years to their sociocultural context in the Jimma zone of Ethiopia (Abessa et al., 2016). It is a multi-dimensional screening tool that consists of 125 items grouped into four developmental domains: 32 GM, 29 FM, 39 LA and 25 personal-social. GM items consist of sitting, walking, jumping and larger muscle movements, FM items consist of eye-hand coordination, manipulation of small objects and problem solving, LA items consist of hearing, understanding and using LA and personal-social items consist of getting along with people and caring for personal needs (Luiz, Foxcroft, & Tukulu, 2004). The test materials consist of a bell, glass bottle, set of ten blocks, rattle, pencil, tennis ball, yam, raisins, cup, white doll, white paper and a baby bottle (Abessa et al., 2016). The test is translated in Amharic and Afan Oromo dialect. It is a culturally relevant, ready to use, inexpensive, easy and fast tool for children up to six years (Abessa et al., 2016). It has a good inter-rater, test-retest reliability and, content validity and can be reliably used in different settings by different professionals.

The test is scored based on 25, 50, 75 and 90 percentile ages of passing the test items. First, the age of a child is calculated and a vertical line is drawn to indicate this. The testing starts with the item completely to the left of the age-line. 'Expected passes' are items passed by 75% or more children of the same and lower age. The raw score of each item consists of 'tested pass', 'implied pass', 'tested failure', 'implied failure', 'refusal' or 'no opportunity'. 'Tested passes' and 'tested failures' are passes and failures obtained by testing the items. 'Implied

passes' are passes obtained if the child passes three consecutive items: all the items left from this are assumed to be passed. 'Implied failures' are failures obtained by failing three consecutive items: all the items right from this are assumed to be failed. The 'implied passes' and 'tested passes' are added up to a total score, the 'actual passes'. From the raw scores categorical and numerical scores can be derived for statistical analysis. The categorical score is a pass ('tested pass') or fail ('tested failure' / 'refusal'). 'No opportunity', 'implied passes' and 'implied failures' are considered missing values. The numerical score is a performance ratio score that is calculated from the 'actual passes' divided by the 'expected passes' to the age of the child. Scores above one are better than expected performances, scores below one are worse than expected performances and scores of one are expected performances taking into account the chronological age of the child (Abessa et al., 2016).

Secondary outcome measures

From the children in extreme poverty secondary outcome measures were taken as well: age of the mother (older or younger than 30 years), education level of the mother (illiterate or literate/education only up to 12^{th} grade), marital status of the mother (divorced/widowed or lives with spouse), occupation of the mother (unstable work or housemaid), monthly income of the mother (less or more than $50), birth order of the child (first born or not) and family size (more or less than three persons). Anthropometric measurements were taken following WHO guidelines as well. Weight was measured with a calibrated electronic weighing scale (SECA Uniscale, Hamburg, Germany). Length was measured with a length-measuring mat on a flat table (SECA 210, Hamburg, Germany) under two years. Children older than two years were measured by using a Seca Road Rod 214 portable Stadiometer. From the reference children anthropometric measurements were taken to determine the nutritional status as well. Mid-upper-arm-circumference (MUAC) was measured with MUAC-tape and weight was measured with a calibrated digital weighing scale. First the developmental assessment and then weight and MUAC were recorded.

2.4 Statistical analysis

Data were analysed with IBM SPSS Statistics 25. First, the children in extreme poverty were matched to the reference children. This was done by using the propensity score matching with

a match tolerance of 0.001. From the originally 1623 children, 45 children could not be matched and had to be excluded: eight children in extreme poverty which were not malnourished, seven children in extreme poverty which were stunted and 30 reference children. In total, 471 children in extreme poverty which were not malnourished, 318 children in extreme poverty which were stunted and 789 children who were reference remained. Descriptive statistics were used to determine the group characteristics (age in months, gender) and the mean performance ratios (GM, FM, LA) of the participants. One-way ANOVA followed by multiple comparison of Tukey was used to compare the mean performance ratios between the groups for GM and LA skills. For FM skills, Welch ANOVA followed by Games-Howell test was used because there was a problem with the homoscedasticity.

Thereafter, the correlations between GM-LA and FM-LA were calculated with two-tailed Spearman's Rho correlation coefficient within the groups because the parametric test showed no normal distribution. To compare the correlations between the groups, the Fisher r to z transformation was used. This was done by the Fisher's Z-test Computator. Subsequently, the children were divided into six age categories which were based on milestones: children between zero and nine months (sit/stand independently and transfer from and into sitting), children between nine and 18 months (walking independently and early linguistic period with two- and more-word sentences), children between 18 and 30 months (differentiation phase of LA development and going to school), children between 30 and 42 months, children between 42 and 54 months and children between 54 and 66 months. For children in extreme poverty and the reference children, the correlations between GM-LA and FM-LA were measured for each age category with the two-tailed Spearman's Rho correlation coefficient. The Fisher z-test compared the correlations between both the groups. At last, the correlations between GM-LA and FM-LA were measured for boys and girls in each group with the two-tailed Spearman's Rho correlation coefficient. The Fisher z-test was used to compare the correlations between the gender and the groups. For all the tests, p -values less than or equal to 0.05 were considered significant.

3. Results

3.1 Descriptive group characteristics

Characteristics for the children in extreme poverty (non-malnourished/stunted) and the reference children can be found in table 1. Children in extreme poverty did not differ from reference children on age (p=0.589) and gender (p=1.000).

Table 1. Characteristics of participants

		Age (months)			**Gender**	
		Mean	Std Dev	Interval	Boys	Girls
Poverty (n=789)		31.00	15.94	4.87-60.90	398	391
	Non-malnourished (n=471)	32.05	16.89	5.33-60.90	229	242
	Stunted (n=318)	29.45	14.29	4.87-60.83	169	149
Reference (n=789)		30.95	15.68	4.96-60.16	398	391

Table 2, summarizes the mean performance ratios for the different developmental domains for the different groups. All children, especially in extreme poverty, showed the lowest mean performance ratios for LA skills. The mean performance ratios for FM and LA skills differed significantly between all the groups. This was not the case for GM skills. No difference in GM skills was found between children in extreme poverty which were not malnourished and reference children. GM performance was poorer in children which were stunted compared to reference children and children in extreme poverty which were not malnourished. On average children in extreme poverty showed a significant smaller mean performance ratio than reference children with the highest mean differences found for LA skills. Children in extreme poverty which were stunted had significantly smaller mean performance ratios than children in extreme poverty which were not malnourished with the highest mean difference for GM skills.

Table 2. Comparison of mean performance ratios for GM, FM and LA between groups

	GM			**FM**			**LA**		
	Mean	Std Dev	Interval	Mean	Std Dev	Interval	Mean	Std Dev	Interval
Poverty	1.036	0.115	0.450-2.000	1.025	0.100	0.529-1.636	0.963	0.132	0.471-1.625

	Non-malnourished	1.064	0.111	0.450-2.000	1.039	0.105	0.529-1.636	0.987	0.135	0.471-1.625
	Stunted	0.994	0.106	0.636-1.273	1.004	0.087	0.714-1.429	0.928	0.120	0.609-1.346
Reference		1.069	0.103	0.786-1.615	1.065	0.117	0.588-1.857	1.025	0.139	0.587-1.714
Between groups		MD		P-value	MD		P-value	MD		P-value
	PNM-R	-0.005		0.648	-0.027		0.0001*	-0.038		0.0001*
	PS-R	-0.075		0.0001*	-0.061		0.0001*	-0.097		0.0001*
	PS-PNM	-0.070		0.0001*	-0.035		0.0001*	-0.059		0.0001*

GM: gross motor skills, FM: fine motor skills, LA: language skills, PNM: poverty non-malnourished, R: reference, PS: poverty stunted, MD: mean difference, *: significance level of 0.05

3.2 Correlations between motor and language skills within and between groups

There was a significant positive correlation between motor and LA skills within all the groups (Table 3). Overall, the strongest correlation was observed between GM and LA skills in children in extreme poverty and for reference children between FM and LA skills. The correlation between FM and LA skills was significantly weaker in children in extreme poverty for both non malnourished and malnourished groups compared to reference children ($p<0.001$). No difference in correlations was found between GM and LA skills between the groups.

Table 3. Correlation between motor and LA skills

		GM- LA		**FM-LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Poverty	*Non-malnourished*	0.431	<0.0001*	0.284	<0.0001*
	Stunted	0.353	<0.0001*	0.183	<0.001*
Reference		0.435	<0.0001*	0.523	<0.0001*
Fisher z-test		z-score	P-value	z-score	P-value
PNM-R		-0.08	0.936	-4.94	0.001*
PS-R		-1.46	0.144	-5.93	0.001*
PS-PNM		-1.27	0.204	-1.47	0.142

GM: gross motor skills, FM: fine motor skills, LA: language skills, PNM: poverty non-malnourished, R: reference, PS: poverty stunted, *: significance level of 0.05

3.3 Correlations between motor and language skills for different age subgroups within and between groups

Children in extreme poverty which were not malnourished showed a significant correlation between GM and LA skills in four of the six age groups namely from nine until 54 months (age subgroups 2,3,4 and 5) with the highest correlation coefficient between 30 and 42 months (subgroup 4) (0.493; $p<0.0001$). The correlation between FM and LA skills started to be

significant at a later age interval from 18-66 months of age (subgroups 3,4,5 and 6) with the highest correlation coefficient between 54 and 66 months of age (subgroup 6) (0.544; p<0.0001).

Children in extreme poverty which were stunted showed a significant correlation between GM and LA skills within two age intervals namely between 18 and 30 months of age (subgroup 3) and between 42 and 54 months of age (subgroup 5) (Table 4). The highest correlation coefficient was found at a later age interval namely between 42 and 54 months of age (subgroup 5) (0.461; p<0.001). Significant correlations between FM and LA skills were found between 18-66 months of age (subgroups 3,4,5 and 6) with the highest correlation coefficient between 42 and 54 months of age (subgroup 5) (0.476; p<0.0001).

Reference children showed a significant correlation between GM and LA skills in all the six age subgroups from birth to 66 months (Table 4) with the highest correlation coefficient from 42 and 54 months of age (subgroup 5) (0.549; p<0.0001). The correlation between FM and LA skills was significant from birth to 66 months of age and strongest between birth and nine months of age (subgroup 1) (0.658; p<0.0001).

Table 4. Correlation between motor and LA skills within different age subgroups

Poverty	*Non-malnourished*	**GM- LA**		**FM- LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Group 1: 0-9m (n=37)		0.322	0.052	0.302	0.069
Group 2: 9-18m (n=98)		0.208	0.040*	-0.021	0.836
Group 3: 18-30m (n=92)		0.468	0.0001*	0.339	0.001*
Group 4: 30-42m (n=80)		0.493	0.0001*	0.506	0.0001*
Group 5: 42-54m (n=109)		0.311	0.001*	0.506	0.0001*
Group 6: 54-66m (n=55)		0.200	0.142	0.544	0.0001*
	Stunted	**GM- LA**		**FM- LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Group 1: 0-9m (n=17)		0.345	0.175	0.126	0.629
Group 2: 9-18m (n=61)		0.195	0.132	0.180	0.164
Group 3: 18-30m (n=102)		0.281	0.004*	0.199	0.045*
Group 4: 30-42m (n=65)		0.208	0.097	0.320	0.009*
Group 5: 42-54m (n=50)		0.461	0.001*	0.476	0.0001*
Group 6: 54-66m (n=23)		0.309	0.152	0.473	0.023*
Reference		**GM- LA**		**FM-LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Group 1: 0-9m (n=49)		0.460	0.001*	0.658	0.0001*

Group 2: 9-18m (n=158)	0.293	0.0001*	0.383	0.0001*
Group 3: 18-30m (n=206)	0.413	0.0001*	0.425	0.0001*
Group 4: 30-42m (n=142)	0.497	0.0001*	0.641	0.0001*
Group 5: 42-54m (n=162)	0.549	0.0001*	0.588	0.0001*
Group 6: 54-66m (n=72)	0.369	0.001*	0.582	0.0001*

GM: gross motor skills, FM: fine motor skills, LA: language skills, *: significance level of 0.05

In table 5, between groups comparison of the correlation between motor and LA skills for different age subgroups is shown. The correlation between GM and LA skills differed significantly in the age subgroup of 42 and 54 months of age (subgroup 5) between children in extreme poverty which were not malnourished and reference children. The correlation between GM and LA skills differed significantly as well in the age subgroup of 30 and 42 months of age (subgroup 4) between children in extreme poverty which were stunted and reference children. The correlation between FM and LA skills differed significantly between children in extreme poverty which were not malnourished and reference children between birth and 18 months of age (subgroup 1 and 2). The correlation between FM and LA skills differed significantly as well between children in extreme poverty which were stunted and reference children between birth and nine months of age and between 18 and 42 months of age (subgroup 1,3 and 4).

Table 5. Correlation between motor and LA skills for different age subgroups between groups

PNM-R		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Group 1: 0-9m		-0.72	0.472	-2.02	0.043*
Group 2: 9-18m		-0.70	0.484	-3.26	0.001*
Group 3: 18-30m		0.54	0.589	-0.79	0.430
Group 4: 30-42m		-0.04	0.968	-1.43	0.153
Group 5: 42-54m		-2.35	0.019*	-0.94	0.347
Group 6: 54-66m		-1.00	0.317	-0.30	0.764
PS-R		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Group 1: 0-9m		-0.56	0.576	-2.17	0.030*
Group 2: 9-18m		-0.68	0.497	-1.44	0.150
Group 3: 18-30m		-1.23	0.219	-2.06	0.039*
Group 4: 30-42m		-2.19	0.029*	-1.80	0.005*
Group 5: 42-54m		-0.71	0.478	-0.94	0.347
Group 6: 54-66m		-0.27	0.787	-0.60	0.549
PS-PNM		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Group 1: 0-9m		0.08	0.936	-0.65	0.516
Group 2: 9-18m		-0.08	0.936	1.22	0.223
Group 3: 18-30m		-1.50	0.134	-1.04	0.298
Group 4: 30-42m		-1.93	0.054	-1.32	0.187
Group 5: 42-54m		1.01	0.313	-0.23	0.818

Group 6: 54-66m	0.44	0.660	-0.36	0.719

GM: gross motor skills, FM: fine motor skills, LA: language skills, PNM: poverty non-malnourished, R: reference, PS: poverty stunted, *: significance level of 0.05

The correlations between motor and LA skills for the different age subgroups are visualized in Figure 1 and 2. In Figure 1, the correlation between GM and LA skills can be followed over time, i.e. the different age intervals. The children in extreme poverty which were not malnourished showed a similar trend of the correlation coefficients over time as the reference children. The correlation starts relatively high, decreases between nine and 18 months of age, thereafter increases to its highest level (between 42 and 54 months of age in reference children) and then decreases again. Children in extreme poverty which were not malnourished reached the highest level earlier: between 30 and 42 months of age. At 42 and 54 months of age the correlation decreased again and was significantly different from reference children, indicated with a blue asterisk (*). On the other hand, children in extreme poverty which were stunted, showed a different trend of the correlation coefficients over time. Before reaching the highest level between 42 and 54 months of age, the correlation decreases a second time between 30 and 42 months of age. This was significantly different from reference children, indicated with a red asterisk (*).

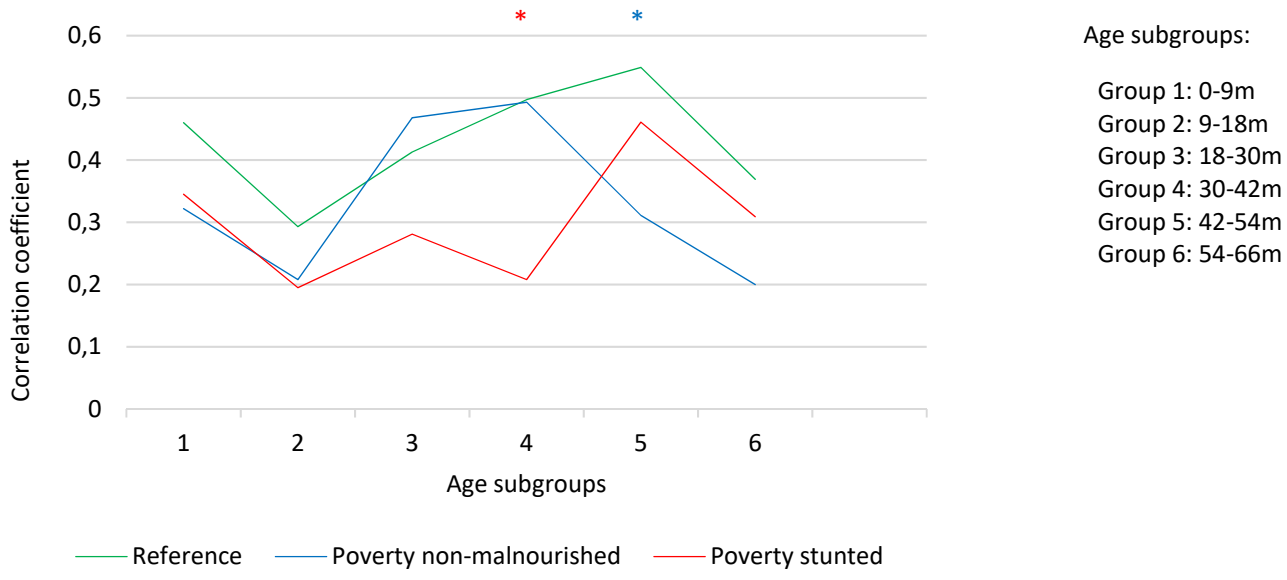

Figure 1. Correlation between GM and LA skills for different age subgroups for children in extreme poverty (with or without malnutrition) and reference children.

In Figure 2, the correlation between FM and LA skills can be found over time. Children in extreme poverty which were not malnourished had a similar pattern as reference children.

The correlation starts relatively high, decreases between nine and 18 months of age, increases steadily until 30 and 42 months of age and then levels off. Between birth and 18 months of age the correlation between FM and LA skills was significant lower in children in extreme poverty which were not malnourished than reference children, indicated with a blue asterisk (*). On the other hand, the correlation between FM and LA skills in children in extreme poverty which were stunted starts relatively low, increases steadily until 42 and 54 months of age and then levels off. These children reached significant lower correlations than reference children between birth and nine months of age and between 18 and 42 months of age, indicated with a red asterisk (*).

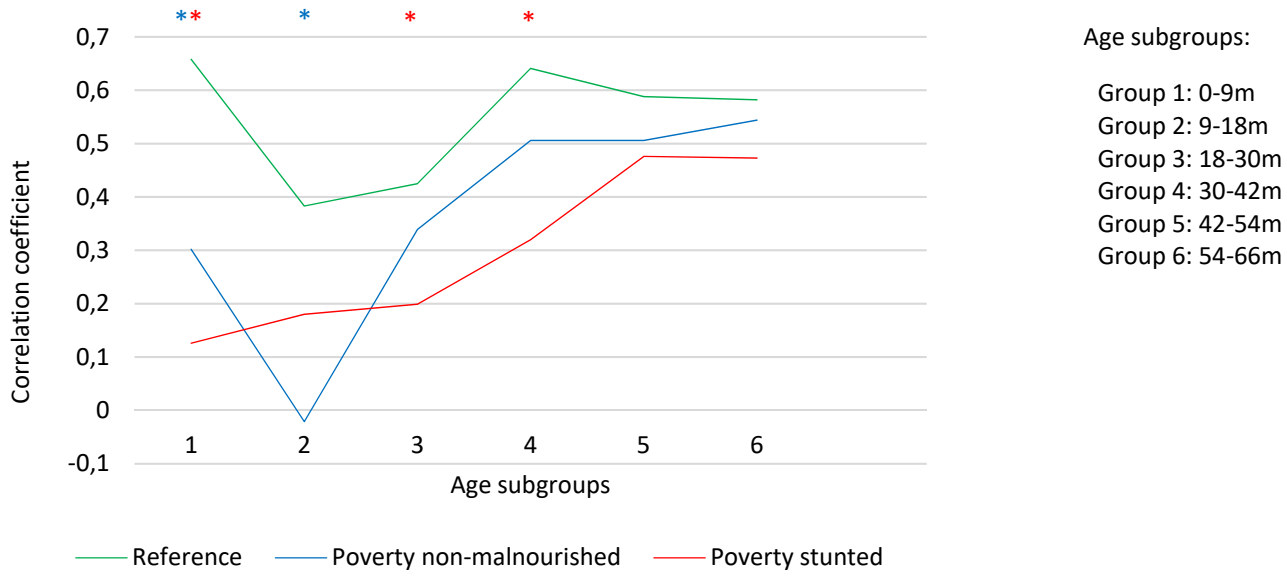

Figure 2. Correlation between FM and LA skills for different age subgroups for children in extreme poverty (with or without malnutrition) and reference children.

3.4 Correlations between motor and language skills for different genders within and between groups

In Table 6, the correlations between motor and LA skills for different genders can be found. The correlation between motor and LA skills was significant in boys and girls in all the groups, except for the correlation between FM and LA skills in girls in extreme poverty which were stunted. The correlation between motor and LA skills did not differ between boys and girls in all the groups ($p>0.05$).

Table 6. Correlation between motor and LA skills between different genders within the same group

Poverty	*Non-malnourished*	**GM- LA**		**FM-LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Boys (n=229)		0.423	0.0001*	0.278	0.0001*
Girls (n=242)		0.441	0.0001*	0.286	0.0001*
Fisher z-test		z-score	P-value	z-score	P-value
		-0.24	0.810	-0.09	0.928
	Stunted	**GM- LA**		**FM-LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Boys (n=169)		0.395	0.0001*	0.213	0.006*
Girls (n=149)		0.292	0.0001*	0.139	0.092
Fisher z-test		z-score	P-value	z-score	P-value
		1.03	0.358	0.67	0.503
Reference		**GM- LA**		**FM-LA**	
		Correlation coefficient	P-value	Correlation coefficient	P-value
Boys (n=398)		0.389	0.0001*	0.476	0.0001*
Girls (n=391)		0.465	0.0001*	0.562	0.0001*
Fisher z-test		z-score	P-value	z-score	P-value
		-1.30	0.194	-1.60	0.110

GM: gross motor skills, FM: fine motor skills, LA: language skills, *: significance level of 0.05

Table 7 shows the between group comparison of the correlation between motor and LA skills for different genders. The correlation between GM and LA skills was significantly lower in girls in extreme poverty which were stunted than reference girls. The correlation between FM and LA skills was significantly lower in boys and girls in extreme poverty than reference children.

Table 7. Correlation between motor and LA skills for a specific gender between groups

PNM-R		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Boys		0.49	0.624	-2.83	0.005*
Girls		-0.37	0.711	-4.15	0.001*
PS-R		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Boys		0.08	0.936	-3.30	0.001*
Girls		-2.09	0.037*	-5.11	0.001*
PS-PNM		**GM- LA**		**FM-LA**	
	Fisher z-test	z-score	P-value	z-score	P-value
Boys		-0.33	0.741	-0.68	0.497
Girls		-1.64	0.101	-1.47	0.142

GM: gross motor skills, FM: fine motor skills, LA: language skills, PNM: poverty non-malnourished, R: reference, PS: poverty stunted, *: significance level of 0.05

4. Discussion

The goal of this master thesis was to have more insight in the correlation between motor and LA skills at children living in extremely poverty and reference children. The most important results are:

1. Significant positive correlations between motor and LA skills were found for children in extreme poverty as for the reference children.
2. The correlation between FM and LA skills was significantly weaker in children in extreme poverty compared to reference children. This was not the case for the correlation between GM and LA skills.
3. The correlation between motor and LA skills did not differ between children in extreme poverty which were stunted and children in extreme poverty which were not malnourished.
4. The correlation between motor and LA skills did not differ between boys and girls within children in extreme poverty and reference children.

4.1 Correlations between motor and language skills within and between groups

Significant positive correlations between the developmental performances of motor and LA skills were found in both children in extreme poverty and reference children. At reference children significant positive correlations between GM and LA skills is in consensus with previous studies on healthy children in developed (Iverson, 2010; Libertus & Violi, 2016; Oudgenoeg-Paz et al., 2015; Oudgenoeg-Paz et al., 2012, 2016; Walle & Campos, 2014) and developing countries (Smeets C., 2016). In contrast correlations between FM and LA skills are hardly studied in previous research. They however, show the strongest correlation within motor skills with LA skills at our reference children. This might be explained by the tight relation of FM skills to LA skills by means of gestures. Children use gestures to refer to object before they have the words to and communicate two pieces of information at the same time before they can use two-word utterances (Iverson & Goldin-Meadow, 2005). Extreme poverty children, on the other hand, showed the strongest correlations between GM and LA skills.

The correlation between FM and LA skills was significantly weaker in children in extreme poverty compared to reference children. Children in extreme poverty spend most of their time playing with whatever is accessible, whenever possible, alone or with peers (Worku et al., 2018). Offering children an optimal physical and social environment in which they can explore objects and that triggers self-locomotion during play, is not evident in an extreme poverty context. The lack of possibilities may contribute into less profit in attaining motor milestones (Oudgenoeg-Paz et al., 2015). In this way absence of the availability of play materials may hamper LA development and a play corner to FM and LA development (Oudgenoeg-Paz et al., 2015; Worku et al., 2018). This could have been a contributing factor to the weaker correlation between FM and LA skills.

The presence of a correlation between motor and LA skills, depended on the age of the children in extreme poverty. Reference children on the other hand showed significant correlations in all the age categories. Extreme poverty children without malnutrition showed more or less the same pattern in correlations over time as reference children. The correlations however were significantly lower than reference children between 42 and 54 months of age between GM and LA skills and between birth and 18 months of age between FM and LA skills. On the contrary, children in extreme poverty which were stunted did not show the same pattern in correlations over time as reference children. Furthermore, they had weaker correlations than reference children between 30 and 42 months of age between GM and LA skills and between birth and nine and 18 and 42 months of age between FM and LA skills. This could be related to muscle atrophy making stunted children less physical active in exploring and interacting with their environment (Briend, Khara, & Dolan, 2015). Children from low-socioeconomic families show indeed reduced overall levels of explorative behaviour and a different developmental trajectory as children of high-socioeconomic families (Clearfield, Bailey, Jenne, Stanger, & Tacke, 2014). In addition they may have attention problems to focus on objects and thus have less interest to gather information, important for both GM and FM skills (Oudgenoeg-Paz et al., 2015).

The correlation between motor and LA skills did not differ between boys and girls within the groups of children in extreme poverty and reference children. Girls in extreme poverty which were stunted had a significant lower correlation between GM and LA skills than reference

girls. Boys and girls in extreme poverty had significantly weaker correlations between FM and LA skills than reference children.

4.2 Strengths and weaknesses

In total, 1623 children were available. This is an important strength within this master thesis. This large sample of participants made substantial age subgroups possible. Another strength is the use of the culturally relevant measurement tool which was standardised to assess child development in the low-income context of the Jimma zone. The original Denver II (Frankenburg et al., 1992) is recently mentioned to be the most feasible and valid test for large scale studies and psychosocial stimulation programs (Rubio-Codina, Araujo, Attanasio, Munoz, & Grantham-McGregor, 2016). The adapted Denver II-Jimma is also reliable and valid for the population in Jimma (Abessa et al., 2016). Measurement tools developed in developed countries, like for instance the Denver II (Frankenburg et al., 1992), are not always valid for use in developing countries and lead to under- or over-referral for services (Abessa et al., 2016; Mendonca, Sargent, & Fetters, 2016). The questionability of the use of the Denver II was for example demonstrated in a study on black preschool children in South Africa (Luiz et al., 2004). Incorrect estimates can be due to positioning and cultural practices, such as caregiver practices that encourage or discourage independent mobility and the lack of access to and familiarity with test items of different racial and ethnic groups (Mendonca et al., 2016). Another strength was blinding of the assessors and the data analyst since the data were already collected before the start of the master thesis.

A limitation of this master thesis is that the data are from two separate consecutive research projects. The reference children were previously sampled to validate the Denver II Jimma. The measurements were, thus, not taken at the same time. Furthermore, the different groups of children were only compared on child gender and age. Not all the baseline measurements were available for all the participants. Other baseline measurements, like age, education level, marital status, occupation and monthly income of the mother, birth order of the child and family size could have had an influence on the outcomes.

4.3 Clinical impact

Investigation of the interaction between motor and LA skills is important knowledge for designing early interventions. Targeting children in childhood as early as possible is crucial, because of the fast development of brain and body during the first two years of life (Aboud & Yousafzai, 2015). The main problem of children in extreme poverty is on the developmental domain LA (Worku et al., 2018) and therefore has to be the main focus in interventions. Since their correlation between FM and LA skills is significantly weaker compared to reference children, early interventions should include FM skills as well. They may have an influence on LA development (Wang et al., 2014). This could be accomplished by means of play-based interventions. Such interventions in combination with nutrition enhance GM, FM (Helmizar, Jalal, Lipoeto, & Achadi, 2017; Nahar et al., 2012; Yousafzai et al., 2016; Yousafzai, Rasheed, Rizvi, Armstrong, & Bhutta, 2014) and LA development (Aboud & Akhter, 2011; Yousafzai et al., 2014). Play-based interventions have to incorporate play materials and a play corner for the optimal learning of FM and LA skills (Worku et al., 2018).

4.4 Recommendations for future research

It would be interesting to start longitudinal studies to investigate the relationship between developmental performances of motor and LA skills at a cohort of children living in extreme poverty compared to reference children to compare with the findings in this cross-sectional design study. Such studies should take into account more baseline measurements like the age, education level, marital and emotional status, occupation and monthly income of the mother, birth order of the child and family size to give more insight into the influence of these characteristics on the findings. In addition, future studies should focus more on the correlation between FM and LA skills. Earlier studies focussed mostly on the GM skills sitting and walking. Based on the findings in this study, the correlation between FM and LA skills should get more attention, especially in developing countries.

5. Conclusion

This master thesis showed that in particular the correlation between FM and LA skills was significantly weaker in children in extreme poverty compared to reference children. The correlation between GM/FM and LA skills did not differ between extreme poverty children without malnutrition and which were stunted. Neither did the correlation between GM/FM and LA skills differ either between boys and girls at children in extreme poverty and reference children. The results indicate that especially FM and LA skills should be targeted within early interventions. For future research, longitudinal studies, incorporating additional baseline characteristics that possibly influence the results, ought to be considered. Furthermore, more attention should be given at the correlation between FM and LA skills rather than GM skills like sitting and walking.

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26/10	Bespreking onderzoeksvraag	Promotor: Copromotor: Student(e): Student(e):
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10/11	Bespreking inleiding	Promotor: Copromotor: Student(e): Student(e):
19/12	Bespreking verloop masterproef.	Promotor: Copromotor: Student(e): Student(e):
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