2015•2016
FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
master in de revalidatiewetenschappen en de kinesitherapie

Masterproef

Correlation between language and motor skills at children with severe acute malnutrition and healthy children under six years old in Ethiopia

Promotor :
Prof. dr. Marita GRANITZER

Copromotor :
De heer Teklu Gemechu ABESSA

Catherine Smeets , Katrien Thierie

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Correlation between language and motor skills at children with severe acute malnutrition and healthy children under six years old in Ethiopia

Contribution to the IUC-JU project 2: Child health and nutrition in Ethiopia

By Catherine Smeets & Katrien Thierie

Master thesis submitted in fulfillment of

the requirements for the degree of master

of Rehabilitation Sciences and Physiotherapy

– paediatric rehabilitation

Supervision by

Prof. Dr. Marita Granitzer, promoter

Drs. Teklu Gemechu Abessa, co-promoter

Acknowledgement

Writing a master thesis was one of the requirements for the degree of master of Rehabilitation Sciences and Physiotherapy - paediatric rehabilitation. We would like to express our gratitude to some important people who supported us during this fulfillment.
Successful completion of this thesis would not be possible without the support of our promoter Prof. Dr. Marita Granitzer. We would like to thank her for the guidance through this process, her support and believe in us. Secondly, we would like to thank our co-promoter Drs. Teklu Gemechu Abessa for providing the data of our thesis and his advice. Also, we would like to thank Jacqueline Materu for her advice about the statistical analysis of our data.

We had the honour and the privilege to write this master thesis in Jimma, Ethiopia. We would like to thank all the people who helped us during our stay, the ones who guided us in the city and helped us with our internships. We are so blessed with having this once-in-a-lifetime experience. We have learned a lot and hope to have been able to contribute to the knowledge of the physiotherapists that are working there.

Last but not least, we would like to thank our family and friends for the unconditional support they gave us this year, not only during the writing process of this master thesis but also during our stay at Jimma. We would particular like to thank our parents for the encouragement throughout our study.

Fazantenstraat 12, 3500 Hasselt, 16/06/2016 C.S.

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Research context

This master thesis relates to paediatric rehabilitation research. It contributes to the project 'Child Health and Nutrition' which is an interuniversity cooperation (IUC) between the Jimma University (JU) and different Flemish universities (IUCJU). Sponsor of this project is the developmental cooperation unit of the Flemish Interuniversity Council (VLIR-UOS). The overall goal of this project is to reduce child mortality, improve child growth and development. The focus of our work was related to interventional research on severe acute malnourished (SAM) children (http://www.iucju.ugent.be). Severely acute malnourished children are enrolled to hospital based interventions. These interventions include treatment of illness associated with malnutrition, nutritional rehabilitation, psychomotor and psychosocial stimulation, which was embodied in the doctoral project of Drs. Teklu Gemechu Abessa, named 'Effects of a play-based family centered psychomotor/psychosocial stimulation on recovery of severely malnourished children of six till 60 months of age during nutritional rehabilitation in the Jimma Zone of Ethiopia'.

Our study aims to evaluate the correlation of language and motor skills in SAM children and healthy children under six years old, in Ethiopia. To do so, the dataset of SAM and healthy reference children of Drs. Teklu Gemechu Abessa's doctoral project was used. Statistical analysis has been done independently.

This master thesis is written by two students of paediatric rehabilitation to serve as a basis for a paper to submit in the journal of Infant behavior and development.

Reference list:
(*) Duchateau, L. The partners of the IUC Partner Programme. IUC-JU. http://www.iucju.ugent.be/prog/part/. Published June, 2009. Accessed March, 2016.

Abstract

Background: Until just recently, several studies highlight the existence of a correlation between language and motor skills, in children with typical and atypical development. Yet no information is available for children with severe acute malnutrition. More knowledge about the correlation between language and motor skills, the co-occurrence of difficulties in both domains or the predictive value from one domain to another within this population of atypically developing might give more insight upon early intervention strategies.

Objectives: The present study aims to evaluate the correlation of language and motor skills in severely malnourished children (SAM) children and healthy children under six years old, in Ethiopia.

Participants: 310 SAM and 310 healthy children under six years, from the Jimma zone in Ethiopia were included. Both groups were matched by gender and age.

Measurements: Developmental status (language, gross and fine motor skills) was assessed using the Denver II – Jimma version. Correlation between language (LA) and gross motor (GM) or fine motor (FM) skills in each group were estimated by the Spearman's Rho correlation coefficient.

Results: LA significantly correlate with both GM and FM in both groups. For the SAM children however a significant weaker correlation between LA and FM was found compared to the healthy children ($p = 0.0008$). Throughout different age intervals strongest significant correlation between LA and GM was observed within the age subgroup of 30 to 42 months (0.5179; $p < 0.0001$) in the SAM children. In healthy children, this was observed at an earlier age subgroup, i.e. 18 to 30 months. In SAM children strongest correlation between LA and FM was from 42 to 54 months (0.5167; $p < 0.0001$) and in healthy children from zero to nine months (0.6589; $p = 0.0104$).

Conclusion: Significant correlations between LA and GM or FM were observed in both groups. However SAM children differ from healthy children by showing weaker correlations and starting at a later stage. Longitudinal interventional studies comparing the correlation between LA and GM or FM, between SAM and healthy children are recommend for future research.

Keywords: Gross motor skills, fine motor skills, language, correlation, severely acute malnourished, children

1. Introduction

Approximately 370,000 children are born every day in the world. These children will learn new skills day by day. Especially the first years of a child's life are critical since the brain develops rapidly. Early experiences as well as their environment affect the organization of a child's brain. Socioeconomic status, parental support, type of home environment may have a serious impact on their development (Leonard and Hill, 2014). Not every child has the same chances to be stimulated in a proper way.

Developmental milestones for children can be classified into different domains: social/emotional, cognitive, self-help, language and motor skills. Achievement of one milestone may imply progress in another. For example, the onset of independent sitting may initiate a cascade that results in increased language opportunities (Libertus and Violi, 2016). Developing motor skills allow the child to interact with the world, with other peers and their parents and gain knowledge of the world (Leonard and Hill, 2014).

Until just recently, several studies show evidence for a correlation between language and motor skills, in children with typical and atypical development (Alcock and Krawczyk, 2010; Iverson, 2010; Iverson and Braddock, 2011; Leonard and Hill, 2014).

In the two longitudinal studies of Wang, Lekhal, Aaro and Schjolberg (2012, 2014) which included 62.944 typically developing children of 18 months to five years old from a Norwegian cohort, correlations between LA and GM or FM and were observed at 18 months, three years and at five years of age, measured by the Ages and Stages Questionnaire. High scores on motor skills at 18 months were associated with high scores on language skills at three years. High scores on language skills at 18 months were associated with lower scores on motor skills at three years, indicating a predictive value from on domain to the other. At 18 months the communicative development is less stable than motor development since the cross-sectional evaluation, this could explain the results (Wang, Lekhal, Aaro and Schjolberg, 2012). The correlation between language and motor skills tended to decrease with age. The systematic review of Leonard and Hill (2014) demonstrated a significant relationship between motor skills and the development of language skills, in typical and atypical children

(Autism Spectrum Disorder, Developmental Coordination Disorder, Specific Language Impairment). Furthermore, the cross-sectional study of Libertus and Violi (2016) shows a significant correlation between LA and GM (sitting) in typically developing children at 10 months and 14 months of age, but no significant correlation for language and FM (grasping), measured at five months of age.

Despite the growing literature of atypical developing children no studies so far made the comparison between malnourished and healthy children for the correlation between language and motor skills. Nevertheless, malnourished children are at higher risk for delays in language, motor, cognitive and social-emotional skills (Jarso, Workicho, Alemseged, 2015). More knowledge about the correlation between language and motor skills within this population might be of support in designing early rehabilitation strategies. This is of high importance since an early identification of problems could prevent problems in later life, especially when the strongest correlation is found in the earliest ages.

From this point of view the present study aims to evaluate the correlation of language and motor skills in SAM and healthy children under six years old, in Ethiopia. Within this goal the dependence of such correlation on nutritional status, age and gender will be analyzed.

2. Methods

2.1 Participants

Within this analysis 310 malnourished and 310 healthy (non-malnourished) children under six years old, from the Jimma zone in Ethiopia, were included. Both groups are matched by gender and age.

SAM children

Inclusion criteria: children aged zero months until six years, children admitted to the nutrition rehabilitation unit at the paediatric ward of the Jimma University's Specialized Referral Teaching Hospital, children of nutritional phase 2 (no medical complications) and transition phase, defined by the criteria from the Ethiopian Federal Ministry of Health, weight-for-height z score less than three and nutritional oedema. SAM children from nutritional phase 1 were excluded.

Development of SAM children was assessed during the transition phase of their treatment with the Denver II- Jimma version. Only children with good appetite and no major complications were tested.

Healthy children

Inclusion criteria: children aged zero months until six years and children whose parents can afford education, such children are supposed to grow up in the middle/higher socio-economical class in Jimma. Some criteria were drafted to exclude children who were potentially developing in an atypical way: prematurity, birth weight below 2500 gram, small body during birth, caesarean section , birth after 24 hours of maternal labour, twins/ triplets, chronical disease, disease in the first year of life, visual or hearing impairment, restrictions of mobility, severe maternal disease during pregnancy and children suspected to be malnourished (weight-for-age and MUAC z-scores referred to WHO 2006 child growth standards).

2.2 Design

Cross sectional data of child development of SAM and healthy children under six years of age have been used to analyze the correlation between language and motor skills within and between each group. Both groups were matched in terms of gender and age.

2.3 Outcome measures

Primary outcomes

The primary outcome is the child's performance in LA, GM and FM. These developmental outcomes for each domain were calculated from the quotient of the number of successful performances, divided by the number of expected performances based on the chronological age of the child. Such performance ratio will be above one when a child passes more test items then expected for his/her age. When a child passes less test items than expected, the performance ratio will be below one. When a child has a score corresponding with the expected performance for his/her age, the performance ratio is one.

$$performance\ ratio\ Denver\ II\ = \frac{number\ of\ successful\ performance}{\text{number of expected performance}}\ for\ each\ domain$$

Secondary outcomes

Nutritional status was determined from the length of the child, the weight of the child and mid upper arm circumference (MUAC). Length was measured using a portable stadiometer and weight with an electronic calibrated weighing scale. MUAC tape measured the circumference of the mid upper arm. All anthropometric measurements were done following the WHO standards (http://www.who.int).

2.4 Instruments

Child development was tested with the Denver II- Jimma, an adapted version of the Denver II test (Frankenburg, 1992) to the socio-cultural context of the children living in Jimma. The Denver II was selected because of covering a large age range (zero – six years), short test duration (20 minutes), low cost, efficiency as a developmental screening tool in low income settings and accessible for local caregivers. The Denver II – Jimma contains 126 items grouped into four domains: personal social (26 items), fine motor (29 items), gross motor (32 items) and language (39 items). Interrater reliability is excellent (0,80<k<1.00) and intrarater reliability is moderate to excellent (Bielen and Orye, 2012). Raw item scoring of the Denver II – Jimma can be done by assigning “Pass”, “Fail”, “No opportunity” or “Refusal”.

2.5 Statistical analysis

To get insight in the data structure of the subdomains LA, GM and FM descriptive statistics where used. In order to get an idea about the correlation between LA and GM or FM the Spearman’s Rho correlation coefficient was used. This non-parametric test was used because the Shapiro- Wilk test showed no normal distribution of the performance ratios of LA, GM and FM.

In order to get an idea about the difference in correlations between SAM and healthy children, and the difference in boys and girls within both groups we calculated the Spearman’s Rho correlation coefficient by nutritional status and gender. In order to explore the evolution of the correlation coefficient with increase of age, the children were divided into age categories. The first category was made from zero till nine months. This first age limit at nine months was chosen because they can sit independently, make transfers from and into sitting and stand independently at this age. The second category was made from nine till 18 months, because at this age children will walk independently. Looking at the normal speech development those children are in the early linguistic period, starting with two- and more-word phrases. The third category was made from 18 till 30 months, because the differentiation phase of language development starts at 30 months and children start to go to school at this age. The forth category was made from 30 till 42 months, the fifth category from 42 till 54 months and the last category from 54 till 72 months. The Spearman's Rho correlation coefficient was used to calculate the correlation between LA and GM or FM, in each age category.

The sign of the correlation coefficient indicates the direction of the correlation ($-1 < r < 1$). The absolute value of the correlation coefficient gives the strength of the correlation. Correlation coefficients between 0.00 and 0.25 indicate no or a small correlation, between 0.25 and 0.50 a proper correlation, between 0.50 and 0.75 a moderate till good correlation and between 0.75 and 1.00 an excellent correlation (Portney, Watkins, 2009). P- values less than or equal to 0.05 were considered significant.

Differences in correlation coefficients between the two independent samples of SAM and healthy children we tested with the Fisher r to z transformation, followed by a formula from Cohen and Cohen that compared these z-scores. For this test significance was set at 0.05, which indicates that the critical value is ± 1.96, values greater than 1.96 were considered significant (http://www.quantpsy.org).

3. Results

3.1 Descriptive group characteristics

Table 1 shows the characteristics of the SAM and the healthy group. Both groups are matched in terms of gender and age. Mean age in both groups was around 30 months.

Table 1 : Participants characteristics

	Age (months)			**Gender**	
	Mean	Std Dev	Interval	Boys	Girls
SAM (n=310)	30.742	15.201	3.055 - 65.741	n=155	n=155
Healthy (n=310)	29.638	15.400	2.957 - 65.807	n=155	n=155

SAM= severely acute malnourished

Table 2 summarizes the mean performance ratios of the SAM children versus the healthy children for the different developmental domains. Mean performance ratios were significantly lower for all developmental domains in the SAM group compared to the healthy group. Within the SAM group, the highest mean score was found for FM and within the healthy group for GM. The largest difference within domain scores between the SAM children and the healthy children, was for GM.

Table 2: Mean performance ratios of GM, FM and LA within SAM and healthy children

	GM			**FM**			**LA**		
	Mean	Std Dev	Interval	Mean	Std Dev	Interval	Mean	Std Dev	Interval
SAM	0.779	0.138	0.286 - 1.250	0.849	0.161	0.000 - 1.167	0.785	0.155	0.231 - 1.192
Healthy	1.076	0.114	0.760 - 1.391	1.064	0.119	0.692 - 2.000	1.026	0.129	0.636 - 1.563
Difference	- 0.297			- 0.215			- 0.241		

SAM= severely acute malnourished, GM= gross motor skills, FM= fine motor skills, LA= language skills

3.2 Correlations between language and motor skills, within and between SAM and heathy children

Both groups showed a significant correlation between LA and GM or FM (Table 3). However a significant weaker correlation between LA and FM was found in the SAM group, compared to the healthy children ($p = 0.0008$). The Fisher z test showed no significant difference between the SAM and healthy children for LA and GM ($p = 0.0919$). In the SAM group the correlation was strongest between LA and GM, in the healthy group between LA and FM.

Table 3: Correlations between language and motor skills, within and between SAM and healthy children

	LA - GM		**LA - FM**	
	Correlation coefficient	P-value	Correlation coefficient	P-value
SAM	0.2884	< 0.0001*	0.2625	< 0.0001*
Healthy	0.4077	< 0.0001*	0.4915	< 0.0001*
Fisher z test	z-score	P-value (sig. two-tailed)	z-score	P-value (sig. two-tailed)
	- 1.6850	0.0919	- 3.3360	0.0008*

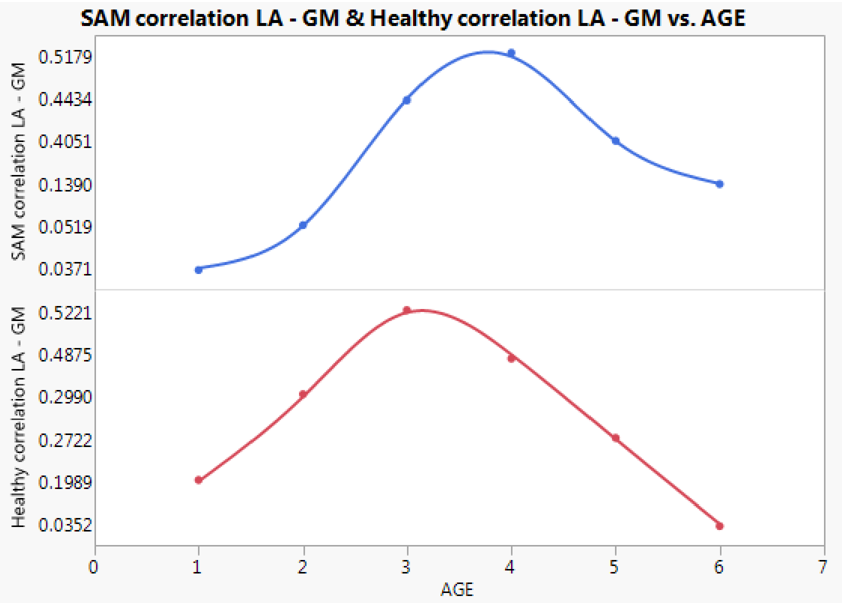
SAM= severely acute malnourished, GM= gross motor skills, FM= fine motor skills, LA= language skills

3.3 Correlations between language and motor skills for different age subgroups, within and between SAM and healthy children

SAM children showed a significant correlation between LA and GM from 18 to 54 months (age subgroups 3, 4, 5) (Table 4). Figure 1 showed higher correlation coefficients for this age band, indicating a stronger correlation between LA and GM from 18 to 54 months. The correlation between LA and GM was strongest from 30 to 42 months (age subgroup 4) (0.5179; $p < 0.0001$). Within the SAM children a significant correlation between LA and FM was observed in the age subgroups from 30 to 54 months (age subgroup 4, 5). Figure 2 showed higher correlation coefficients for this age band, indicating a stronger correlation between LA and GM from 30 to 54 months. The correlation between LA and FM was strongest from 42 to 54 months (age subgroup 5) (0.5167; $p < 0.0001$).

The healthy children showed a significant correlation between LA and GM from nine to 42 months old (age subgroups 2, 3, 4) (Table 4), and thus at an earlier age compared to the SAM children. Figure 1 showed higher correlation coefficients for this age band, indicating a stronger correlation between LA and GM from nine to 42 months. The correlation between LA and GM was strongest within the age subgroup of 18 to 30 months old (age subgroup 3) (0.5221; p < 0.0001). All age subgroups till 54 months showed a significant correlation between LA and FM, and thus at an earlier age compared to the SAM children. In this group of healthy children, the correlation between LA and FM was the strongest at zero to nine months (age subgroup 1) (0.6589; p = 0.0104)(Figure 2).

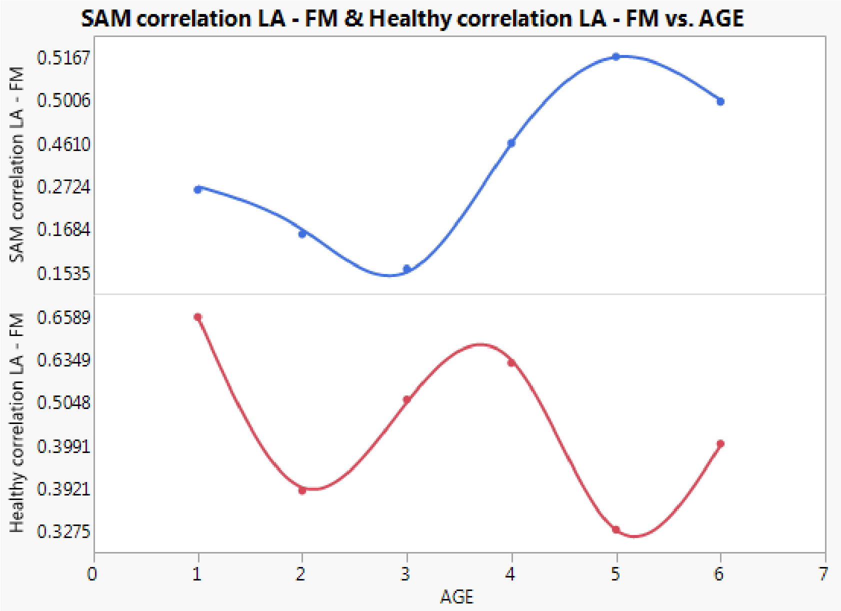
Figure 1 and 2 show the correlation between LA and GM or FM for the different age groups within SAM and healthy children. Same evolutions of the correlation between LA and GM for SAM and healthy children were observed in figure 1. Starting with a lower correlation in the early ages, increasing to a higher correlation in the mid and decreasing to a lower correlation at the end. SAM children showed this evolution at a later age, compared to the healthy children. For LA and FM, the evolution in correlation coefficients was different in both groups, showing a higher correlation at the end for the SAM children and a fluctuating evolution for the healthy children.



Age subgroups:

1) 0-9m
2) 9-18 m
3) 18-30 m
4) 30-42 m
5) 42-54 m
6) 54-66 m

Figure 1: Correlations between LA and GM for the different age subgroups within SAM and healthy children



Age subgroups:

1) 0-9m
2) 9-18 m
3) 18-30 m
4) 30-42 m
5) 42-54 m
6) 54-66 m

Figure 2: Correlations between LA and FM for the different age subgroups within SAM and healthy children

Table 4: Correlations between language and motor skills for different age subgroups within SAM and healthy children

SAM	**LA - GM**		**LA - FM**	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Group 1: 0-9 m (n=12)	0.0371	0.9089	0.2724	0.3916
Group 2: 9-18 m (n=67)	0.0519	0.6764	0.1684	0.1731
Group 3: 18-30 m (n=80)	0.4434	< 0.0001*	0.1535	0.1740
Group 4: 30-42 m (n=72)	0.5179	< 0.0001*	0.4610	< 0.0001*
Group 5: 42-54 m (n=52)	0.4051	0.0029*	0.5167	< 0.0001*
Group 6: 54-66 m (n=27)	0.1390	0.4893	0.5006	0.0078
Healthy	**LA - GM**		**LA - FM**	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Group 1: 0-9 m (n=14)	0.1989	0.4955	0.6589	0.0104*
Group 2: 9-18 m (n=77)	0.2990	0.0082*	0.3921	0.0005*
Group 3: 18-30 m (n=77)	0.5221	< 0.0001*	0.5048	< 0.0001*
Group 4: 30-42 m (n=66)	0.4875	< 0.0001*	0.6349	< 0.0001*
Group 5: 42-54 m (n=52)	0.2722	0.0509	0.3275	0.0178*
Group 6: 54-66 m (n=24)	0.0352	0.8701	0.3991	0.0534

SAM= severely acute malnourished, GM= gross motor skills, FM= fine motor skills, LA= language skills

3.4 Correlations between language and motor skills for boys and girls, within and between SAM and healthy children

Within the SAM group no significant differences in correlations between boys and girls were found for LA and GM (p = 0.5369) and for LA and FM (p = 0.3638) (Table 5). Strongest correlation in the group of SAM children was found between LA and GM in boys (0.3236; p < 0.0001) (Table 5).

Within the healthy group no significant differences in correlations between boys and girls were found for LA and GM (p = 0.7653) and for LA and GM (p = 0.2262) (Table 5). In the healthy group strongest correlation was found in girls for FM and LA (0.5378; p < 0.0001)(Table5).

A significant weaker correlation was found in SAM children for boys and girls between LA and FM, compared to healthy children (boys: p=0.0338, girls: p=0.0153) (Table 5). Boys and girls showed a weaker correlation in SAM children for LA and GM, compared to healthy children, but this difference in correlation was not significant (boys: p=0.4744, girls: p= 0.1028)(Table 6).

Table 5: Correlations between language and motor skills for different genders, within and between SAM and healthy children

SAM	**LA - GM**		**LA - FM**	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Boys	0.3236	<0.0001*	0.2154	0.0073*
Girls	0.2588	<0.0011*	0.3122	< 0.0001*
Fisher z test	z-score	p-value (sig. two-tailed)	z-score	p-value (sig. two-tailed)
	0.6180	0.5369	- 0.9080	0.3638
Healthy	**LA - GM**		**LA - FM**	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Boys	0.3950	< 0.001*	0.4319	< 0.0001*
Girls	0.4235	< 0.001*	0.5378	< 0.0001*
Fisher z test	z-score	p-value (sig. two-tailed)	z-score	p-value (sig. two-tailed)
	- 0.2980	0.7653	- 1.2100	0.2262

SAM= severely acute malnourished, GM= gross motor skills, FM= fine motor skills, LA= language skills

Table 6: Difference in correlation between boys and girls for language and motor skills, between SAM and healthy children

	LA - GM		LA - FM	
	z-score	P-value (sig. two-tailed)	z-score	P-value (sig. two-tailed)
Boys	-0.7150	0.4744	-2.1220	0.0338*
Girls	-1.6310	0.1028	-2.4240	0.0153*

GM= gross motor skills, FM= fine motor skills, LA= language skills

4. Discussion

The aim of this study was to investigate the correlation of language and motor skills within and between SAM children and healthy children.

Since the past five years there is increasing evidence for a correlation between language and motor skills in children with a typical development, but also in children with an atypical development (SLI, DCD, ASD, …). Such finding offers interesting perspectives for clinical applications.

As mentioned in our introduction, analysis on severely malnourished children is lacking. However, since such children show developmental delays such knowledge is crucial to intervene as soon as possible in the most optimal way.

The most eye-catching results within our study are a significant correlation between LA and GM or FM in both groups, a weaker correlation between LA and FM in SAM children compared to healthy children and no significant difference between the SAM and healthy children for LA and GM. SAM children however showed a significant correlation between LA and GM at a later age i.e. 18 till 54 months than healthy children (from nine to 42 months). Same evolutions of the correlation between LA and GM for SAM and healthy children were observed. SAM children however showed this evolution at a later age. SAM children showed a significant correlation between LA and FM at a later age i.e. from 30 to 54 months than healthy children (from zero till 54 months). In both groups, no significant differences in correlations between boys and girls were found for LA and GM or FM.

4.1 Correlations between language and motor skills, within and between SAM and healthy children

Clinical interest is growing for the correlation between language and motor skills in children with an atypical development. There is also evidence that malnutrition has a negative influence on the development of children (Gladstone et al; 2014). Within our study the lower performances of the SAM group, for all developmental domains compared to the healthy group, confirm these results. The largest difference between SAM and healthy children was found for GM.

In both groups a significant correlation between LA and GM or FM was found. However, weaker correlations were observed for the SAM compared to the healthy children. This difference in correlation seemed not to be significant for LA and GM. Weak correlations may imply discrepancies between LA and GM or FM. One hypothesis suggests that the difficulties in these two developmental domains (language and motor skills) are not symptoms of two separate domains but a manifestation of a common underlying neurodevelopmental weakness (Wang, Lekhal, Aaro, Schjolberg, 2012, 2014). Co-occurring deficits in both domains, in children with an atypical development were described by Leonard & Hill (2014). Bishop (2002) explains the correlation between language and motor development by genetic influences. This is contradictory with our results, since SAM children in our study weren't born with a risk of atypical development but develop in an atypical way because of their life circumstances.

<u>4.2 Correlations between language and motor skills for different age subgroups, within and between SAM and healthy children</u>

SAM children showed a significant correlation between LA and GM from 18 months to 52 months. Before this age, no significant correlation was found. Yet, before the age of 18 months the period is very critical to learn fundamental motor skills as independent sitting, crawling and walking. An explanation for the absence of a correlation in this critical time period might be their weakness, development of SAM children might be delayed and they might move along those early motor milestones at later age.

Healthy children showed a significant correlation between LA and GM from nine to 42 months old. These results can be confirmed by the study of Libertus & Violi (2016), who investigated the early gross motor skills in infants at 10 and 14 age of months. Their findings suggest that the onset of independent sitting may initiate a developmental cascade that results in increased language learning opportunities. These results are consistent with the main results of the longitudinal study of Wang, Lekhal, Aaro and Schjolberg (2012, 2014) for children from 18 months to three years and in children from three to five years. The authors believe that development of one domain may predict development of the other one. They observed a significant positive association between motor skills at 18 months and language at three years and early language performance (three years) seemed to predict gross and fine motor skills in a positive way at a later stage (five years). Their results support the previous theory of Iverson (2010) that early motor acquisitions provide infants to explore the world and have an impact on general communicative development at a later stage. In our results the strongest correlation, between LA and GM skills, was found in the age subgroup of 18 till 30 months, confirming the previous theories that motor skills in this time period have a great influence on language.

One of the explanations why we find a correlation between language and motor skills in young children is the theory of embodied cognition perspective. This theory suggests that thoughts are influenced by action, including the influence of action on language. So the body and the way you use it to explore the world has a big impact on shaping the mind (Iverson, 2010; Alcock & Krawczyk, 2010).

The healthy children showed a slightly stronger correlation between LA and FM skills compared to LA and GM skills. It seems that first the correlation between LA and GM was stronger (18-30m) and at later age the correlation between LA and FM (30-42m).

Same evolutions of the correlation between LA and GM for SAM and healthy children were observed in graph 1. SAM children showed this evolution at a later age. Because of their weakness, development of SAM children might be delayed and they might move along the motor milestones at later age.

4.3 Correlations between language and motor skills for boys and girls, within and between SAM and healthy children

In both groups, no significant differences in correlations between boys and girls were found for LA and GM or FM. This confirms the results of the longitudinal study of Wang et al. (2014).

4.4 Clinical impact

During the first 18 months of life, infants acquire a whole set of new motor skills that significantly change the way they interact with the environment and the relationship with other peers and adults. Iverson (2010) argued that motor acquisitions provide infants an opportunity to practice relevant language skills. These findings are confirmed by different studies. In the study of Wang, Lekhal, Aaro and Schjolberg (2012) early motor skills (18 m) predicted later communication skills (three years). Also Leonard & Hill (2014) underlined the fact that practitioners should be aware of the impact that early motor problems can affect later social relationships, due to difficulties in language skills. Libertus & Violi (2016) suggest independent sitting initiate learning language opportunities.

In this study, we find evidence for the theory mentioned above in the group of healthy children. We did find a correlation between LA and GM or FM. In LA and GM the correlation is the strongest between 18 and 30 months. As physiotherapists we do believe that this period plays a critical role in the later development of children. Early intervention in the stimulation of GM is recommended when developmental milestones aren't reached.

In the SAM group the role of the environment needs to be considered. Psychomotor stimulation can be used in a preventive way to decrease the effect of malnutrition on the development. Because of the weak correlation, specific individual rehabilitation programs are recommended in the SAM group. Not only psychomotor stimulation is needed but also language and cognitive development intervention programs need to be considered.

Due to the fluctuating correlations, the assessment of language and motor skills in early childhood should be continuous rather than measured at one single point in the healthy group and the SAM children.

4.5 Strengths and limitations

The published articles use different samples and/or measuring methods, therefor it is difficult to draw clear conclusions that can be compared with the new insights of our statistical analysis. Another limitation is that we only investigated the correlation between LA and GM or FM. The correlations with LA and gestures or oral motor movements were not investigated.

This is the first study with a population of SAM children. Other strengths of this study are the large number of participants (n=620) and high reliability of the used developmental screening tool (Denver II Jimma).

5. Conclusion

A significant correlation between LA and GM or FM was observed, in both groups. However SAM children differ from healthy children by showing weaker correlations and starting at a later stage. Yet gross motor function around 18 months is an important aspect in the development of language skills in later life in healthy children and thus urges for early intervention.

Recommendations for future research certainly are longitudinal interventional studies that compare the correlation between LA and GM or FM between malnourished children and children with a typical development.

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Correlation between language and motor skills at children with severe acute malnutrition and healthy children under six years old in Ethiopia

Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij kinderen**
Jaar: **2016**

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Datum: **16/06/2016**