Early Child Development and Care

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/gecd20

Improvements in babies' neuropsychomotor development after family-centered Kids Intervention Therapy – Aquatic Environment (KITE): biopsychosocial approach

Luize Bueno de Araujo, Tainá Ribas Mélo & Vera Lúcia Israel

EARLY CHILD DEVELOPMENT AND CARE
https://doi.org/10.1080/03004430.2022.2048828

Improvements in babies' neuropsychomotor development after family-centered Kids Intervention Therapy – Aquatic Environment (KITE): biopsychosocial approach*

Luize Bueno de Araujo [a], Tainá Ribas Mélo [a,b] and Vera Lúcia Israel [a,c]

[a]Physical Education Postgraduation Program, Federal University of Paraná, Curitiba, Brazil; [b]Department of Public Health, Federal University of Paraná, Matinhos, Brazil; [c]Department of Physical Therapy Prevention and Rehabilitation, Federal University of Paraná, Curitiba, Brazil

ABSTRACT

The objective of this study was to verify the effects on 4- to 18-month-old babies' NPMD after the family-centered Kids Intervention Therapy – Aquatic Environment (KITE) programme. This quasi-experimental study involved 61 families. The NPMD was assessed with Alberta Infant Motor Scale (AIMS), Denver II Developmental Screening Test, context assessment with questionnaire and Affordance in the Home Environment for Motor Development – Infant Scale (AHEMD-IS), and quality of life (QOL) assessment with Pediatric Quality of Life Inventory™ Infant Scales (PedsQL™). 24 babies in the intervention group (IG) participated in the KITE session twice a week for 4 weeks. 37 children participated in the control group. The IG sample had improved NPMD in post-intervention ($p = 0.001$) and retention ($p = 0.002$), with a large intervention effect (η = 0.178/0.156). The IG improved in the QOL physical capacity domain ($p = 0.023$), with a medium effect (d = 0.573). There were no differences between the groups regarding the stimulation received at home, which reinforces the effects of the KITE. It is concluded that the KITE had positive effects on the NPMD and QOL physical capacity domain in the participating.

ARTICLE HISTORY
Received 22 February 2022
Accepted 25 February 2022

KEYWORDS
Child development; early intervention; hydrotherapy; International Classification of Functioning Disability and Health

Introduction

The first thousand days of life – a period of intense neuroplasticity that favours the development of children's potentialities – are crucial to neuropsychomotor development (NPMD). Hence, it is considered optimal for early intervention programmes (EIP) (Johnson, 2016; Macy, 2015).

It is estimated that more than 200–250 million children under 5 years old who live in developing countries are exposed to various factors that prevent their full NPMD (Black et al., 2017; Grantham-McGregor et al., 2007). About 25 (Walker et al., 2011) to 43% (Black et al., 2017) of children in these countries are at risk of delays. Given the external environment and/or internal organic influences on this dynamic process – which have lifelong consequences (Cioni, Inguaggiato, & Sgandurra, 2016) –, all children, especially the ones exposed to risk factors, should be included in NPMD follow-up programmes to identify delays or changes, and then plan EIP for them (Araujo, Mélo, & Israel, 2017; Araujo, Quadros, Murata, & Israel, 2019; Formiga & Linhares, 2011).

CONTACT Luize Bueno de Araujo luizebueno@hotmail.com

*We extend our gratitude to all families and babies who participated in the research, to the Municipal Department of Education of Curitiba, Paraná, Brazil, and the principals and teams of the participating daycare centers.

Programmes that approach aquatic motor activities stand out among the growing number of studies that aim to prove the effects of EIP (Fragala-Pinkham, Dumas, Barlow, & Pasternak, 2009; McManus & Kotelchuck, 2007). Family-centered programmes for babies, with the active participation of relatives, tend to be more successful (Blauw-Hospers, de Graaf-Peters, Dirks, Bos, & Hadders-Algra, 2007), increasing the likelihood of benefits for the children. However, few studies have been conducted with satisfactory methodological quality to analyze the effects of such interventions on small children's NPMD (Antúnez, Guisado, & Fuentes, 2012; Gorter & Currie, 2011).

Likewise, there are few studies on EIP with a biopsychosocial (BPS) approach in child health care, addressing the systematized NPMD assessment of the domains in the International Classification of Functioning, Disability, and Health (ICF), namely: function and structure, activities and participation, and environmental and personal factors (Araujo, Novakoski, Bastos, Mélo, & Israel, 2018; Mélo, Araujo, Novakoski, & Israel, 2019). This is due to the heterogeneity of the studies, inadequate sample size, non-standardized instruments for comparison, and focus on function and structure – i.e. on the children's disease and limitations. This indicates the need for further research in this field of study, also addressing the possible effects of interventions in different contexts, such as EIP in aquatic environments (Araujo, Mélo, & Israel, 2020; Borato et al., 2021).

Hence, the objective of this research was to verify the effects of a family-centered kids intervention therapy – aquatic environment (KITE) with a BPS approach on the NPMD of 4- to 18-month-old babies.

Methodology

This research was approved by the Ethics Committee of the Federal University of Paraná (UFPR), CAAE: 57193516.6.0000.0102, evaluation report no. 1.714.810, and Brazilian Registry of Clinical Trials (ReBEC) RBR – 2hd6sm.

This quantitative controlled interventional (Hochman, Nahas, Oliveira Filho, & Ferreira, 2005) quasi-experimental study (Timmons et al., 2012) blindly assessed the effects of the KITE (Araujo et al., 2020) with the ICF BPS model (Mélo, Araujo, Novakoski, et al., 2019) on the NPMD and quality-of-life (QOL) outcomes, with stimulation at home as the control variable.

The inclusion criteria were as follows: babies of both sexes, aged 4–18 months, attending public municipal daycare centres in the capital of a state in the South Region of Brazil, whose participation was permitted by their parents and/or guardians by signing an informed consent form. Infants with congenital malformations, signs of neurological changes, genetic syndromes, sensory changes, history of congenital infections (STORCH-HIV) diagnosed in the neonatal period, malformations that might influence speech, and visual and/or auditory changes (Brito, Vieira, Costa, & Oliveira, 2011) were excluded. Babies with skin lesions or infectious and contagious diseases, without a medical certificate allowing pool activities, or who were participating in another aquatic stimulation programme were excluded from the aquatic activities.

The sample calculation was verified with G*Power 3.1.9.2 software, assuming a 0.25 effect size, 0.05 type I error, and 0.95 analysis power in a 3:1 proportion of typical children in relation to those with developmental delay or at risk in three assessment moments, indicated the need for 44 sample participants.

The research flowchart is shown in Figure 1. The babies' NPMD assessment 1 (pre-intervention) for the functions and structures and activities and participation was conducted with the Alberta Infant Motor Scale (AIMS) and Denver II Developmental Screening Test and, for the context (personal and environmental factors), with the child questionnaire, personal child health record, socioeconomic questionnaire of the Brazilian Association of Research Companies (ABEP, in Portuguese), mother–child relationship, Affordance in the Home Environment for Motor Development – Infant Scale (AHEMD-IS), and Pediatric Quality of Life Inventory™ Infant Scales (PedsQL™). Based on the NPMD assessment with AIMS and Denver II, the babies were stratified into two groups (typical

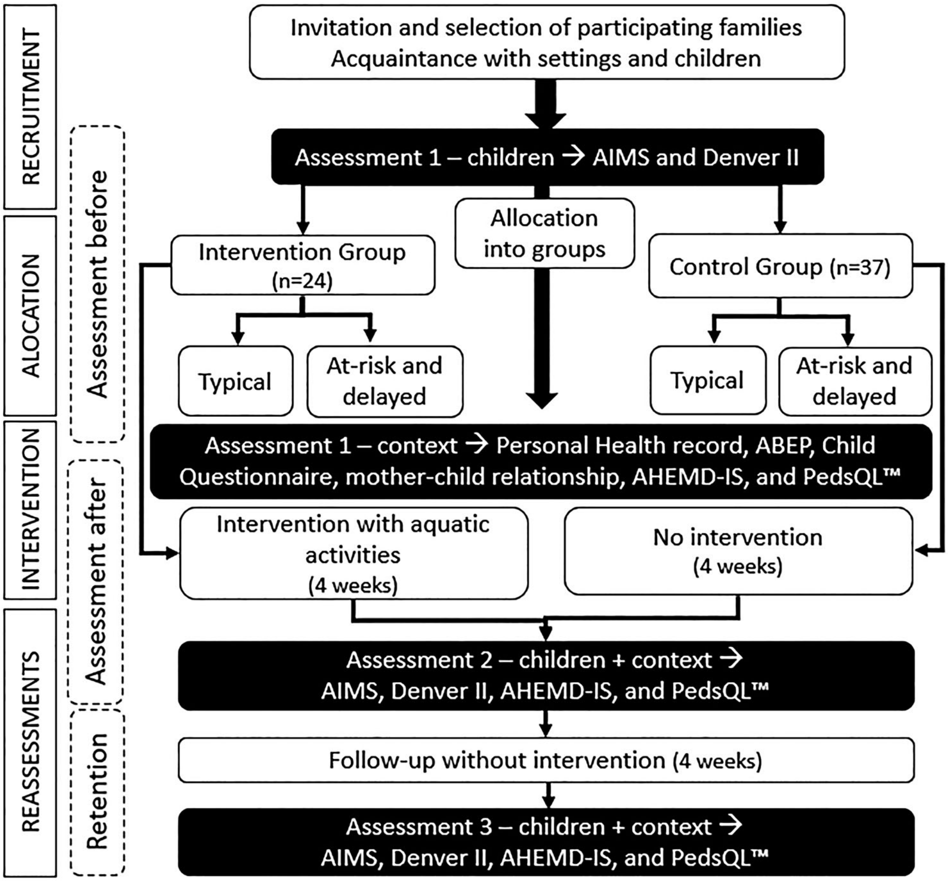

Figure 1. Flowchart of the research.

and delayed/at-risk), according to convenience (family's interest in and availability to participate in the KITE), allocated into control group (CG) and intervention group (IG).

The IG participated in the KITE, whose protocol was developed in a previous study (Araujo et al., 2020), with fun aquatic intervention activities lasting 45–60 min to avoid fatigue in the small children (McManus & Kotelchuck, 2007), twice a week, totalling 4 weeks (Gorter & Currie, 2011).

The CG did not participate in the intervention or receive guidance during the research. The participants of both groups attended daycare centres during the collection period. After the collection was finished, the CG was informed about the assessment results and received home stimulation instructions.

After 4 weeks, all babies were submitted to assessment 2 (post-intervention) with AIMS, Denver II, AHEMD-IS, and PedsQL™. After another 4 weeks without interventions, they were submitted to assessment 3 (retention or follow-up) with the same instruments used in assessment 2 to verify whether the results were maintained after 1 month without any interventions.

The scales were applied at the daycare centres, always by the same rater, after reliability analysis. The Intraclass Correlation Coefficient for AIMS (ICC > 0.9) was excellent (Koo & Li, 2016). In Denver II, the intra-rater reliability was excellent (100%; kappa = 1) and the inter-rater agreement was good (91%; kappa = 0.792) (Sim & Wright, 2005).

The analyses were made with the Statistica software, version 7, and SPSS, version 20. The normality was verified with the Shapiro–Wilk test, and the homogeneity of the variances, with the Levene test. The groups were compared with the Fisher chi-square test, Student's t-test, and Mann–Whitney test. The pre- and post-intervention and retention were compared with the McNemar and Friedman tests. The paired comparisons – pre- with post-intervention and post-intervention with retention – were made with the Wilcoxon test. The effect size was assessed by calculating the η^2 coefficient (eta square) and Cohen's d coefficient (Cohen effect size), in which an η^2 up to 0.039: small effect; from 0.04–0.11: medium effect; and above 0.11: large effect; and Cohen's d up to 0.4: small effect; from 0.4–0.7: medium effect; and above 0.7: large effect (Valentini & Saccani, 2012). For the comparative analyses of KITE effects, the babies had to be grouped into delayed and at-risk, due to sample representativity.

Results

Altogether, 61 babies participated in the research – 37 in the CG and 24 in the IG. IG's mean attendance to the eight interventions was 7.21 (90%). The sample characterization per group is shown in Table 1.

The groups were homogeneous, without significant differences between them regarding most of the children's initial characteristics, neonatal and gestation characteristics, and family characteristics. CG had more cases of previous abortions ($p = 0.046$) than IG; more participants in IG had an adequate income (>R$ 2,000.00) ($p = 0.049$), and the father was the householder more often in IG ($p = 0.007$).

There was no significant difference between the groups in the initial NPMD ($p = 0.74$), AIMS ($p = 0.20$), Denver II ($p = 0.53$), QOL (PedsQL™) ($p = 0.46$), and home stimulation (AHEMD) ($p = 0.40$).

Table 2 presents the frequencies of the children with overall NPMD, AIMS, and Denver II classification and the comparison between IG and CG, divided into typical and delayed/at-risk NPMD at the three moments – pre-intervention, post-intervention, and retention. In the beginning, the groups were similar; however, after the KITE, the number of typical children in the CG decreased, while the number of typical children in the IG increased at post-intervention ($p = 0.001$) and retention ($p = 0.002$), with a large intervention effect ($\eta^2 = 0.178$ and 0.156).

The data on the intragroup intervention effect are shown in Table 3. It shows no significant change in CG throughout the research, whereas IG shows a considerable increase in typical cases at post-intervention, with a large effect ($\eta^2 = 0.173$), which was stabilized at retention.

The delay/at-risk cases decreased in both groups in assessment 2 (Table 4), with a medium intervention effect in IG ($\eta^2 = 0.055$). At retention, there was one less baby delayed/at risk in CG, while the cases were maintained in IG. There was no significant change in AIMS classification in either group throughout the study.

According to Denver II (Table 4), the number of babies at risk increased in CG, while in IG the babies at risk decreased and the typical ones increased, with a large effect in IG, from pre- to post-intervention ($p = 0.041$; $\eta^2 = 0.173$). This result is ratified (Table 5) by the significant increase in babies with typical NPMD, with a medium effect at post-intervention ($p = 0.01$; $\eta^2 = 0.105$) and large effect at retention ($p < 0.001$; $\eta^2 = 0.195$).

Concerning the QOL with PedsQL™ (Table 6), the KITE had a significant medium effect on intragroup physical capacity at post-intervention ($p = 0.023$; $d = 0.573$). There was no difference between the moments in the other domains – physical symptoms, emotional aspects, social interaction, cognition, and total.

There was no significant change in the AHEMD-IS classification regarding home stimulation. This was used as a control variable of the KITE effects.

Discussion

The KITE had positive effects on NPMD. There were differences between the groups at post-intervention and retention, which indicates improved performance immediately after the intervention in IG and learning with a large intervention effect at the two moments.

Table 1. Sample characterization per group.

	Variable	Measure	Categories	Control (n = 37)	Intervention (n = 24)	*p*
Initial characteristics of the children	Sex	n (%)	males	17 (45.95)	15 (62.50)	0.20
	Age	mean ± SD	months	10.37 ± 2.92	11.53 ± 3.35	0.16
		CI		5.1–15.4	4–16	
	Age at enrolment	mean ± SD	months	7.88 ± 2.91	8.57 ± 3.47	0.35
		CI		4–14	3–14	
	Time in day care	mean ± SD	months	2.38 ± 2.11	2.83 ± 2.56	0.29
		CI		0.5–10	0.5–12	
	NPMD according to parents	n (%)	typical	36 (97.30)	21 (87.50)	0.16
	Technology use	n (%)	yes	24 (64.86)	14 (58.33)	0.61
	Walker use	n (%)	yes	11 (29.73)	5 (20.83)	0.44
	Nutritional status	n (%)	well-nourished	31 (83.78)	21 (87.50)	0.50
Neonatal characteristics and gestation	Birth weight	mean ± SD	kg	3216.36 ± 442.08	3184.96 ± 318.71	0.76
		CI		2450–4275	2510–3880	
	Birth length	mean ± SD	cm	47.97 ± 2.52	48.55 ± 2.00	0.31
		CI		41–53	42–52	
	Head circumference	mean ± SD	cm	34.01 ± 1.47	33.81 ± 1.21	0.53
		CI		30–36.50	31–36	
	1-minute Apgar	mean ± SD	score	8.56 ± 1.25	8.17 ± 1.55	0.25
		CI		2–9	3–10	
	5-minute Apgar	mean ± SD	score	9.44 ± 0.81	9.38 ± 0.82	0.79
		CI		6–10	7–10	
	Prematurity	n (%)	no	37 (100.00)	22 (91.67)	0.15
	Gestational age	mean ± SD	months	39.15 ± 0.74	38.97 ± 1.17	0.83
		CI		38–42	36–40.5	
	Type of delivery	n (%)	normal	16 (43.24)	11 (45.83)	0.84
	Previous abortion	n (%)	yes	11 (29.73)	2 (8.33)	0.046*
	High-risk pregnancy	n (%)	yes	12 (32.43)	8 (33.33)	0.94
	Breastfeeding	mean ± SD	months	4.19 ± 2.37	4.15 ± 2.44	0.84
		CI		0–7.5	0–7	
Family characteristics	ABEP	n (%)	B1 + B2	17 (45.95)	9 (37.5)	0.53
	Family income	mean ± SD	R$	2996 ± 1963	3643 ± 1831	0.16
		CI		260–10000	1200–8000	
		n (%)	adequate	24 (64.86)	21 (87.50)	0.049*
	Householder	n (%)	father	13 (35.14)	15 (62.50)	0.007*
	Father's educational levels	n (%)	HSC	17 (50.00)	10 (41.67)	0.06
	Mother's educational levels	n (%)	HSC	14 (37.84)	12 (50.00)	0.76
	Father's age	mean ± SD	years	31.57 ± 7.88	31.54 ± 7.01	0.92
		CI		19–54	19–43	
	Mother's age	mean ± SD	years	29.57 ± 6.23	27.63 ± 5.26	0.21
		CI		20–43	19–40	
	Number adults	mean ± SD	number	2.54 ± 1.32	3.00 ± 1.59	0.31
		CI		1–7	2–7	
	Number children	mean ± SD	number	1.49 ± 0.65	1.42 ± 0.65	0.67
		CI		1–3	1–3	
	Father's daily time	mean ± SD	hours	2.42 ± 2.01	3.5 ± 2.03	0.08
		CI		0–6	0–7	
	Mother's daily time	mean ± SD	hours	4.82 ± 1.63	5.19 ± 2.16	0.71
		CI		2–10	2–13	
	Single mother	n (%)	yes	12 (32.43)	3 (12.50)	0.08
	Absent father	n (%)	yes	11 (29.73)	3 (12.50)	0.12
	Mother-child relationship	n (%)	adequate	30 (83.33)	21 (87.50)	0.48
NPMD	NPMD	n (%)	typical	20 (54.05)	14 (58.33)	0.74
			at-risk/delayed	17 (49.95)	10 (41.67)	
	AIMS	n (%)	typical	23 (62.16)	19 (79.17)	0.20
			at-risk/delayed	14 (37.84)	5 (20.84)	
	Denver II	n (%)	typical	26 (70.27)	15 (62.50)	0.53
			at-risk/delayed	11 (29.73)	9 (37.50)	
QOL	PedsQL™	mean ± SD	Total	75.59 ± 11.01	77.60 ± 9.04	0.46
		CI		50.50–93.00	61.83–91.33	

(*Continued*)

Table 1. Continued.

	Variable	Measure	Categories	Control (n = 37)	Intervention (n = 24)	*p*
Stimulation received	AHEMD-IS	n (%)	Excellent	11 (29.73)	9 (37.50)	0.40
			Adequate	13 (35.14)	9 (37.50)	
			Moderately adequate	9 (24.32)	6 (25.00)	
			Less than adequate	4 (10.81)	0 (0.00)	

Noes: SD = standard deviation; CI = confidence interval; n = number; HSC = High School Complete; NPMD = Neuropsychomotor development; ABEP = Brazilian Association of Research Companies; QOL = Quality of life; AHEMD-IS = Affordance in the Home Environment for Motor Development-Infant Scale $*p < 0.05$. Chi-square and Mann-Whitney test.

Table 2. Effects of the KITE between groups on overall development classification.

	Pre-intervention		Post-intervention		Retention	
NPMD	CG	IG	CG	IG	CG	IG
Typical	20 54.05%	14 58.33%	15 40.54%	20 83.33%	18 48.65%	21 87.50%
At-risk/delayed	17 45.95%	10 41.67%	22 59.46%	4 16.67%	19 51.35%	3 12.50%
Total	37	24	37	24	37	24
p	0.74		0.001*		0.002*	
η^2	0.001		0.178		0.156	

Notes: NPMD = neuropsychomotor development; CG = control group; IG = intervention group; $*p < 0.05$; η^2 = eta square. Chi-square test.

Table 3. Effects of the KITE within the groups on neuropsychomotor development.

	CG		IG	
	p	η^2	*p*	η^2
Pre x Post	0.13	0.061	0.04*	0.173
Post x Retention	0.37	0.021	1.00	<0.001

Notes: CG = control group; IG = intervention group; $*p < 0.05$; η^2 = eta square. McNemar test.

Table 4. Effects of the KITE within the groups on neuropsychomotor development classification with AIMS and Denver II.

		CG			IG		
		Pre	Post	Retention	Pre	Post	Retention
AIMS	Typical	23 62.16%	24 64.86%	25 67.57%	19 79.17%	22 91.67%	22 91.67%
	At-risk/delayed	14 37.84%	13 35.14%	12 32.43%	5 20.83%	2 8.33%	2 8.33%
	Total	37	37	37	24	24	24
	p		1.00*	1.00**		0.25*	0.48**
	η^2		0	0		0.055	0.020
Denver II	Typical	26 70.27%	21 56.76%	18 48.65%	15 62.50%	21 87.50%	22 91.67%
	At-risk/delayed	11 29.73%	16 43.24%	19 51.35%	9 37.50%	3 12.50%	2 8.33%
	Total	37	37	37	24	24	24
	p		0.13	0.45		0.041*	1.00
	η^2		0.061	0.015		0.173	0.00

Notes: AIMS = Alberta Infant Motor Scale; CG = control group; IG = intervention group; n = number; η^2 = eta square; * *p*-value of the pre X post comparison; ** *p*-value of the post X retention comparison. McNemar test.

Table 5. Effects of the intervention on the neuropsychomotor development between the groups with Denver II.

	Pre-intervention		Post-intervention		Retention	
Denver II	CG	IG	CG	IG	CG	IG
Typical	26 70.27%	15 62.50%	21 56.76%	21 87.50%	18 48.65%	22 91.67%
At-risk/delayed	11 29.73%	9 37.50%	16 43.24%	3 12.50%	19 51.35%	2 8.33%
Total	37	24	37	24	37	24
p	0.53		0.01*		<0.001*	
η^2	0.006		0.105		0.195	

Notes: CG = control group; IG = intervention group; η^2 = eta square, *$p < 0.05$. Chi-square test.

Table 6. Effects of the intervention on the quality of life between and within groups.

	Pre		Post		Retention			
	CG (n = 37)	IG (n = 24)	CG (n = 37)	IG (n = 24)	CG (n = 37)	IG (n = 24)		
PHYSICAL CAPACITY (%)								
	CG	IG	CG	IG	CG	IG	*p* (inter)	
Mean	77.67	78.76	72.97	81.25	76.32	82.58	0.23	0.92
SD	13.35	13.20	14.52	14.32	16.47	14.23		
p (intra)	0.75		0.023*		0.12		d	
d	0.082		0.573		0.400		0.188	0.331
TOTAL (%)								
	GC	GI	GC	GI	GC	GI	*p* (inter)	
Mean	75.59	77.60	77.57	78.83	76.08	78.95	0.83	0.34
SD	11.01	9.04	9.25	11.55	10.03	9.48		
p (intra)	0.51		0.51		0.37		d	
d	0.195		0.123		0.292		0.248	0.314

Notes: CG = control group; IG = intervention group; n = number; SD = standard deviation; *p* = *p*-value; d = Cohen d; *$p < 0.05$; Inter = intergroup; Intra = intragroup. Student's t-test and Friedman test.

The assessments were conducted blindly at the daycare centres, ensuring the greater methodological quality of the research and greater inferences on the effects being related to the KITE. There is no consensus in the literature regarding either positive or negative influences of daycare on the children's NPMD (Becker & Piccinini, 2019; Laurin, Geoffroy, Boivin, Japel, & Raynault, 2015; Yamaguchi, Silva, Araujo, Guimarães, & Israel, 2019), which is why the sample comprised only babies who attended daycare centres. Moreover, the results pointed to improved performance, which is probably not due to maturation because the CG performed worse.

These findings show that the neuropsychomotor stimulation provided by daycare was not enough to change the children's delayed/at-risk condition or maintain them in typical parameters – which justifies submitting all babies to intervention, including the ones evaluated as typical in assessment 1. In the systemic and contextual model, this may be explained by the influence of factors related to the individual (body functions and structures and personal factors), the environment (environmental factors), and the task (activity and participation). These are aspects of human development throughout life, according to the ICF BPS model (Araujo et al., 2018; Mélo, Araujo, Novakoski, et al., 2019).

The separate analysis of the NPMD outcome with AIMS showed that the delayed/at-risk cases decreased in both groups in assessment 2 – one less case in CG and three less in IG, with a medium intervention effect in IG. At retention, there was one less case in CG and maintained cases in IG, with no significant changes.

No value or score was found in the literature representing a minimally significant clinical change for AIMS. However, every child who leaves the delayed/at-risk zone is already considered a satisfactory clinical result. Using the classification on the scale, even if the child evolved and improved their motor skills, such gains may not be enough to place them in typical parameters, which limits the statistical changes. This also occurs because the analysis grouped the delayed and at-risk children in a single group because of the sample size in the respective groups. Dias, Manoel, Dias, and Okazaki (2013) also report difficulties with the sample size and discriminatory power of AIMS to verify differences between the groups and the effect of the aquatic intervention.

The NPMD analysis with Denver II showed that KITE had a large intervention effect, with the same trend for retention. The number of delayed/at-risk babies increased in CG, whereas in IG the at-risk cases decreased, and the typical ones increased. The comparison between the groups also revealed differences at post-intervention and retention, respectively with medium and large intervention effects.

This analysis makes clear the relevance of following up babies over time and providing stimuli to all of them. The study by Anderson (2018) highlights that motor development goes beyond acquiring motor skills, as it is interconnected with and contributes significantly to all other domains in the development. Learning to move has implications to NPMD that extend much further than motor control and interact with cognitive, affective, emotional, sensory, perceptual, and socio-environmental aspects (Araujo & Israel, 2017). This highlights the essentiality of a broader look to NPMD, encompassing different assessment and intervention domains, as proposed in this research through the ICF.

The effects of the programme on NPMD, assessed with Denver II, is in line with the systematization of the KITE (Araujo et al., 2020), with a psychomotor approach that involves language, cognition, planning, affections, emotions, family training, social interaction, and stimulation of active and self-initiated movements.

This research had a family-centered, fun approach, in which the babies' parents/guardians were protagonists of the stimulation, being trained during the interventions and receiving instructions to continue them at home. Novak (2020) highlights that family-centered care is essential, rather than optional, to provide effective care, while McCoy et al. (2020) suggest that training and enabling parents to play with their children is essential to effective treatment. The study by McCoy et al. (2020) confirmed that the children's participation is up to four times better when the therapy is family-centered and meets the parents' and children's needs. Also, the children who are stimulated with fun, recreative activities are 2.5 times as likely to progress 'more than expected' (Novak, 2020).

The differential of this research is that it actively involves the children's parents/guardians in the KITE stimulation process, in an environment that requires care, attention, and protection, providing mutual interaction and learning (Moulin, 2007), with positive evidence of the effect of the intervention on NPMD and QOL.

The KITE was developed with fun activities, functional objectives related to the mobility section in the ICF activity and participation domain, and transference to the children's real environment. The article by Angeli, Schwab, Huijs, Sheehan, and Harpster (2021) points to the ICF as an excellent, robust, multidimensional tool with emphasis on the function to establish and define pediatric intervention goals. Hence, ICF use is promoted in therapeutic practice as a means to improve the effectiveness and quality of the goals, ensuring an adequate and relevant intervention. The way the KITE is organized, with goals systematized according to the ICF and a combination with out-of-pool function, may have helped it reach its objectives.

Specifically, the study by Güeita-Rodríguez et al. (2017) verified, from the families' perspective, that aquatic physical therapy influenced both the body functions and the activity and participation components in the children. These findings reinforce the relevance of the KITE, whose practice with the babies is focused on BPS and the main objective is to influence the study children's functioning (activity and participation).

The findings presented in this study, with results in the babies' NPMD, may be related to the characteristics of the KITE: fun family-centered neuropsychomotor stimulation in a stimulus-rich environment, combined with the neuroplasticity principles described by Kleim and Jones (2008) – as neuroplasticity and motor learning require stimulation (Araujo et al., 2020). Fun, pleasant, and motivating stimuli (which can be achieved in an aquatic environment) (Iucksch et al., 2020) are known to have a greater skill acquisition potential. Likewise, repetition is essential, which makes domestic programmes indispensable to continuing the stimuli and reaching the necessary intensity (Spittle & Morgan, 2018).

The KITE stimulations were applied in the aquatic environment and allowed the babies to have diversified motor and sensory experiences to potentialize their development (Araujo et al., 2020; Pereira, Valentini, Saccani, & Dázevedo, 2011). These experiences were made possible by the movements of both the water and immersed body, the heated water and environment, the reassuring presence of family in the stimulations, the fun activities and music, and the interaction between participants and their families. These various sensory stimuli contribute to neurofunctional maturation and synaptic and neuronal organization, which are essential in this phase of life (Sale, Hannan, Maffei, & Guzzetta, 2013).

This sensory perception caused by hydrostatic pressure in the aquatic environment (Muñoz-Blanco et al., 2020) has been studied in research on immersion and cortical activity (Sato et al., 2012). The authors verified that immersion increases the cerebral cortical activity in the somatosensory areas, which occurs because immersion is a multimodal (tactile, pressure, and thermosensitive) form of somatosensory stimulation. This suggests that water immersion can help the person improve their motor skills and learn new ones (Sato et al., 2012), thanks to neuroplasticity in cortical areas of learning and memory (Sato et al., 2020).

The possibility of transferring acquired experience through problem-solving when adapting to the aquatic environment enables the babies to develop their adaptability. Hence, they transfer strategies learned in the pool to other environments and everyday situations, whose challenges they need to overcome (Moulin, 2007). Children's development takes place through interactions between them, the environment, and the task (Araujo & Israel, 2017). Studies show that more complex tasks involving attention, memory, or motor demands seem to have a more significant impact on neuroplastic changes (Carey, Bhatt, & Nagpal, 2005). Such complexity was proposed in the KITE, with activity progressions and increments.

The stimulation promoted by the KITE enables children to broaden their motor skills and develop physical, cognitive, and sensory aptitudes to use various strategies and actively perform their skills. For instance, the necessary balance strategies and reactions using floatation material in various densities, providing various floatation possibilities; the challenges posed in the sequence of activities and exploration of movements in different environments – such as ramps, steps, platforms, and trampolines. Along with these, the movements progressed with increasing difficulty, taking advantage of the physical, static, and dynamic principles imposed by the aquatic environment (Israel, 2008).

Aquatic physical therapy provides to the children the possibility of experiencing, learning, and enjoying new movement skills. In addition to the physical benefits, it can also improve their QOL and self-reliance (Adar et al., 2017) and positively influence behaviours related to mental health and the child's well-being (Mills, Kondakis, Orr, Warburton, & Milne, 2020).

The effects of the KITE on the QOL were assessed with PedsQL™. The score in the physical capacity domain was significantly higher for IG in post-intervention, with a medium effect, possibly due to the correlation between this domain and NPMD, as previously pointed out by Mélo, Araujo, Yamaguchi, Ferreira, and Israel (2020).

The QOL data were collected from family reports, which shows that the family noticed these changes. This restates the results of the KITE in the participation of children who attend the programme, as well as the extrapolation of gains to the environment to which they belong. This corroborates the study by Reedman, Boyd, and Sakzewski (2017), which demonstrates this need for pediatric interventions that develop strategies to increase the children's participation.

As in this research, the study by Mélo, Araujo, Ferreira, and Israel (2019) verified improved physical capacity after EIP was conducted at daycare centres. The study by McManus and Kotelchuck (2007) found that children who participated in aquatic intervention combined with home visits had greater functional mobility gains. Improvements in these physical capacity items may be associated with the benefits of the activities conducted in the aquatic environment.

The lack of studies on the QOL of babies without an established diagnosis and the little use of this outcome as a measure for the effects of intervention programmes hinders the comparison of the analyzed data (Mélo et al., 2020).

In this sense, the effects of the KITE were ratified by both the effects identified in the IG babies and the use of AHMED-IS as a control variable – which did not identify any significant difference in the stimulation received at home regarding physical space, and the variety of stimulations and toys for fine motor coordination.

In the limitations of this study and recommendations for further research, the randomization of daycare centres and CG and IG babies stands out, as well as a greater sample whose number makes it possible to stratify groups into typical, at-risk, and delayed children. Moreover, motor behaviours in the aquatic environment must be assessed with a standardized instrument, such as AFAS Baby (Araujo et al., 2020). Another suggestion is to investigate in depth the stimulation practices at home and school. EIP with protective actions in early childhood must be an integral part of routine practices, being implemented through public policies to ensure access to all. The aquatic interventions may also be helpful for those children with disabilities.

Conclusions

The KITE, through promotion, intervention, and participation in an aquatic environment, had positive effects on the NPMD of typical and delayed/at-risk babies, as well as motor learning through retention, with a large intervention effect. The programme also improved the QOL physical capacity domain, with a medium effect. The KITE did not provide changes in the stimulation received at home, which ratifies the effects of the programme.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by CAPES [Grant Number 001].

Financing information

This paper was conducted with support from CAPES – Finance Code 001.

Notes on contributors

Luize Bueno de Araujo contributed to project conceptualization, data collection, programme application, data analysis and interpretation, writing, and approval of the final version of the article; ***Tainá Ribas Mélo*** contributed to project conceptualization, data collection, assessment of participants, writing and approval of the final version of the article; ***Vera Lúcia Israel*** contributed to data collection, programme application, project review, writing and approval of the final version of the article.

ORCID

Luize Bueno de Araujo http://orcid.org/0000-0001-9795-4043
Tainá Ribas Mélo http://orcid.org/0000-0002-7630-8584
Vera Lúcia Israel http://orcid.org/0000-0001-5824-7792

References

Adar, S., Dündar, Ü, Demirda, ÜS, Ulaşlı, A. M., Toktaş, H., & Solak, Ö. (2017). The effect of aquatic exercise on spasticity, quality of life, and motor function in cerebral palsy. *Turkish Journal of Physical Medicine and Rehabilitation*, *63*(3), 239–248. doi:10.5606/tftrd.2017.280

Anderson, D. I. (2018). Motor development: Far more than just the development of motor skills. *Kinesiology Review*, *7*(2), 99–114. doi:10.1123/kr.2018-0011

Angeli, J. M., Schwab, S. M., Huijs, L., Sheehan, A., & Harpster, K. (2021). ICF-inspired goal-setting in developmental rehabilitation: An innovative framework for pediatric therapists. *Physiotherapy Theory and Practice*, *37*(11), 1167–1176. doi:10.1080/09593985.2019.1692392

Antúnez, L. E., Guisado, C. I. G., & Fuentes, M. T. M. (2012). Efectividad de la hidroterapia en atención temprana. *Fisioterapia*, *34*(2), 79–86. doi:10.1016/j.ft.2011.11.003

Araujo, L. B., & Israel, V. L. (2017). Como é o processo de desenvolvimento da criança nos primeiros 2 anos de idade? *Desenvolvimento da Criança: Família, Escola e Saúde*, *1*(1), 1–14. doi:10.7436/2017.dcfes.01

Araujo, L. B., Mélo, T. R., & Israel, V. L. (2017). Low birth weight, family income and paternal absence as risk factors in neuropsychomotor development. *Journal of Human Growth and Development*, *27*(3), 272–280.

Araujo, L. B., Mélo, T. R., & Israel, V. L. (2020). Kids Intervention Therapy - Aquatic Environment (KITE) for babies 4 to 18 months old, by following the International Classification of Functioning (ICF): clinical trial protocol. *Motriz*, *26*(1), e10200223. doi:10.1590/s1980-6574202000010223

Araujo, L. B., Novakoski, K. R. M., Bastos, M. S. C., Mélo, T. R., & Israel, V. L. (2018). Characterization of the neuropsychomotor development of children up to three years old: The ICF model in the context of the family health support center. *Cadernos Brasileiros de Terapia Ocupacional*, *26*(3), 538–557. http://www.cadernosdeterapiaocupacional.ufscar.br/index.php/cadernos/article/view/1973/1013

Araujo, L. B., Quadros, D. A., Murata, M. P. F., & Israel, V. L. (2019). Neuropsychomotor development assessment of children aged 0 to 5 in early childhood public education centers. *Revista CEFAC*, *21*(3), 1–9. doi:10.1590/1982-0216/201921312918

Becker, S. M. da S., & Piccinini, C. A. (2019). Impacto da Creche para a Interação Mãe-Criança e para o Desenvolvimento Infantil. *Psicologia: Teoria e Pesquisa*, 35, e3532. https://doi.org/10.1590/0102.3772e3532

Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., … Grantham-McGregor, S. (2017). Advancing Early Childhood Development: From Science to Scale 1: Early childhood development coming of age: Science through the life course early childhood development series steering committee HHS public access. *Lancet*, *389*(10064), 77–90. doi:10.1016/S0140-6736(16)31389-7

Blauw-Hospers, C. H., de Graaf-Peters, V. B., Dirks, T., Bos, A. F., & Hadders-Algra, M. (2007). Does early intervention in infants at high risk for a developmental motor disorder improve motor and cognitive development? *Neuroscience and Biobehavioral Reviews*, *31*(8), 1201–1212. doi:10.1016/j.neubiorev.2007.04.010

Borato, M., Souza, S. F., Biernaski, J., Lucas, D. F., Carvalho, B. K., Mélo, T. R., … Israel, V. L. (2021). Avaliação fisioterapêutica aquática para crianças: uma revisão integrativa. *Revista Contexto & Saúde*, *21*(42), 25–37. doi:10.21527/2176-7114.2021.42.11551

Brito, C. M. L., Vieira, G. O., Costa, M. d. C. O., & Oliveira, N. F. d. (2011). Desenvolvimento neuropsicomotor: o teste de Denver na triagem dos atrasos cognitivos e neuromotores de pré-escolares. *Cadernos de Saúde Pública*, *27*(7), 1403–1414. doi:10.1590/S0102-311X2011000700015

Carey, J. R., Bhatt, E., & Nagpal, A. (2005). Neuroplasticity promoted by task complexity. *Exercise and Sport Sciences Reviews*, *33*(1), 24–31.

Cioni, G., Inguaggiato, E., & Sgandurra, G. (2016). Early intervention in neurodevelopmental disorders: Underlying neural mechanisms. *Developmental Medicine and Child Neurology*, *58*, 61–66. doi:10.1111/dmcn.13050

Dias, J. A. B. S., Manoel, E. J., Dias, R. B. M., & Okazaki, V. H. A. (2013). Pilot study on infant swimming classes and early motor development. *Perceptual and Motor Skills*, *117*(3), 950–955. doi:10.2466/10.25.PMS.117(30z2

Formiga, C. K. M. R., & Linhares, M. B. M. (2011). Motor development curve from 0 to 12 months in infants born preterm. *Acta Paediatrica*, *100*(3), 379–384. doi:10.1111/j.1651-2227.2010.02002.x

Fragala-Pinkham, M. A., Dumas, H. M., Barlow, C. A., & Pasternak, A. (2009). An aquatic physical therapy program at a pediatric rehabilitation hospital: A case series. *Pediatric Physical Therapy*, *21*(1), 68–78. doi:10.1097/PEP.0b013e318196eb37

Gorter, J. W., & Currie, S. J. (2011). Aquatic exercise programs for children and adolescents with cerebral palsy: What do we know and where do we go? *International Journal of Pediatrics*, *2011*, 1–7. doi:10.1155/2011/712165

Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Child development in developing countries 1 developmental potential in the first 5 years for children in. *Lancet*, *369*, 60–70.

Güeita-Rodríguez, J., García-Muro, F., Rodríguez-Fernández, ÁL, Lambeck, J., Fernández-de-las-Peñas, C., & Palacios-Ceña, D. (2017). What areas of functioning are influenced by aquatic physiotherapy? Experiences of parents of children with cerebral palsy. *Developmental Neurorehabilitation*, *21*(8), 506–514. doi:10.1080/17518423.2017.1368728

Hochman, B., Nahas, F. X., Filho, O., de, R. S., & Ferreira, L. M. (2005). Desenhos de pesquisa. *Acta Cirurgica Brasileira*, *20*(suppl 2), 2–9. doi:10.1590/S0102-86502005000800002

Israel, V. L. (2008). Hidroterapia com bebês especiais: um caminho diferente. In Bolsanello, M. A. (org.). In: Simpósio Nacional de Atenção e Estimulação Precoce. Laboratório de Estimulação e Atenção Precoce de Bebês (LABEBÊ), 1. Atenção e estimulação precoce: bebês com deficiência. (p. 110).

Iucksch, D. D., Araujo, L. B., Novakoski, K. R. M., Yamaguchi, B., Carneiro, C. F., Mélo, T. R., & Israel, V. L. (2020). Decoding the aquatic motor behavior: Description and reflection on the functional movement. *Acta Scientiarum - Health Sciences*, *42*(1), 1–11. doi:10.4025/actascihealthsci.v42i1.47129

Johnson, B. (2016). Early intervention in children with developmental disabilities. *BMH Medical Journal*, *3*(1), 1–4.

Kleim, J. A., & Jones, T. A. (2008). Principles of experience-dependent neural plasticity: Implications for rehabilitation after Brain damage. *Journal of Speech Language and Hearing Research*, *51*(1), S225. doi:10.1044/1092-4388(2008/018)

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. doi:10.1016/j.jcm.2016.02.012

Laurin, J. C., Geoffroy, M., Boivin, M., Japel, C., & Raynault, M. (2015). Child care services, socioeconomic inequalities, and academic performance. 136(6). doi:10.1542/peds.2015-0419

Macy, M. (2015). Promising practices, models, and research in the early identification of young children with disabilities. *Journal of Intellectual Disability – Diagnosis and Treatment*, *3*(4), 154–155.

McCoy, S. W., Palisano, R., Avery, L., Jeffries, L., Laforme Fiss, A., Chiarello, L., & Hanna, S. (2020). Physical, occupational, and speech therapy for children with cerebral palsy. *Developmental Medicine and Child Neurology*, *62*(1), 140–146. doi:10.1111/dmcn.14325

McManus, B. M., & Kotelchuck, M. (2007). The effect of aquatic therapy on functional mobility of infants and toddlers in early intervention. *Pediatric Physical Therapy*, *19*(4), 275–282. doi:10.1097/PEP.0b013e3181575190

Mélo, T. R., Araujo, L. B., Ferreira, M. d. P., & Israel, V. L. (2019). Effects of an early intervention program by the ICF model on the neuropsychomotor development and quality of life in babies in daycare. *Early Child Development and Care*, *191*(13), 2103–2115. doi:10.1080/03004430.2019.1691545

Mélo, T. R., Araujo, L. B., Novakoski, K. R. M., & Israel, V. L. (2019). Systematization of evaluation instruments for the two first years of life of typical or risk infants according to the ICF model. *Fisioterapia e Pesquisa*, *26*(4), 380–393. doi:10.1590/1809-2950/18026126042019

Mélo, T. R., Araujo, L. B., Yamaguchi, B., Ferreira, M. d. P., & Israel, V. L. (2020). Quality of life and neuropsychomotor development of infants between 4–18 months in daycare center. *Ciencia e Saude Coletiva*, *25*(8), 3175–3184. doi:10.1590/1413-81232020258.21002018

Mills, W., Kondakis, N., Orr, R., Warburton, M., & Milne, N. (2020). Does hydrotherapy impact behaviours related to mental health and well-being for children with autism spectrum disorder? A randomised crossover-controlled pilot trial. *International Journal of Environmental Research and Public Health*, *17*(2). doi:10.3390/ijerph17020558

Moulin, J. (2007). Baby swimming: Effects of swimming courses on infant development. *Journal de Pédiatrie et de Puériculture*, *20*, 25–28. doi:10.1016/j.jpp.2006.12.006

Muñoz-Blanco, E., Merino-Andrés, J., Aguilar-Soto, B., García, Y. C., Puente-Villalba, M., Pérez-Corrales, J., & Güeita-Rodríguez, J. (2020). Influence of aquatic therapy in children and youth with cerebral palsy: A qualitative case study in a special education school. *International Journal of Environmental Research and Public Health*, *17*, 10. doi:10.3390/ijerph17103690

Novak, I. (2020). Therapy for children with cerebral palsy: Who, what, and how much? *Developmental Medicine and Child Neurology*, *62*(1), 17. doi:10.1111/dmcn.14345

Pereira, K. R. G., Valentini, N. C., Saccani, R., & Dázevedo, H. A. (2011). Influência de atividades aquáticas no desenvolvimento motor de bebês. *Revista da Educacao Fisica*, *22*(2), 159–168. doi:10.4025/reveducfis.v22i2.9644

Reedman, S., Boyd, R. N., & Sakzewski, L. (2017). The efficacy of interventions to increase physical activity participation of children with cerebral palsy: A systematic review and meta-analysis. *Developmental Medicine and Child Neurology*, *59*(10), 1011–1018. doi:10.1111/dmcn.13413

Sale, A., Hannan, A. J., Maffei, L., & Guzzetta, A. (2013). Noninvasive strategies to optimise brain plasticity: From basic research to clinical perspectives. *Neural Plasticity*, *2013*. doi:10.1155/2013/863970

Sato, D., Onishi, H., Yamashiro, K., Iwabe, T., Shimoyama, Y., & Maruyama, A. (2012). Water immersion to the femur level affects cerebral cortical activity in humans: Functional near-infrared spectroscopy study. *Brain Topography*, *25*(2), 220–227. doi:10.1007/s10548-011-0204-z

Sato, D., Yamashiro, K., Yamazaki, Y., Ikarashi, K., Onishi, H., Baba, Y., & Maruyama, A. (2020). Priming effects of water immersion on paired associative stimulation-induced neural plasticity in the primary motor cortex. *International Journal of Environmental Research and Public Health*, *17*, 1. doi:10.3390/ijerph17010215

Sim, J., & Wright, C. C. (2005). The kappa statistic in reliability studies: Use, interpretation, and sample size requirements. *Physical Therapy*, *85*(3), 257–268. doi:10.1093/ptj/85.3.257

Spittle, A. J., & Morgan, C. (2018). Early intervention for children with cerebral palsy. In *Cerebral palsy: A multidisciplinary approach* (pp. 193–200). Springer International Publishing. doi:10.1007/978-3-319-67858-0_18

Timmons, B. W., LeBlanc, A. G., Carson, V., Connor Gorber, S., Dillman, C., Janssen, I., … Tremblay, M. S. (2012). Systematic review of physical activity and health in the early years (aged 0–4 years). *Applied Physiology, Nutrition, and Metabolism*, *37*(4), 773–792. doi:10.1139/h2012-070

Valentini, N. C., & Saccani, R. (2012). Brazilian validation of the Alberta Infant motor scale. *Physical Therapy*, *92*(3), 440–447. doi:10.2522/ptj.20110036

Walker, S. P., Wachs, T. D., Grantham-Mcgregor, S., Black, M. M., Nelson, C. A., Huffman, S. L., … Richter, L. (2011). Inequality in early childhood: Risk and protective factors for early child development. *The Lancet*, *378*(9799), 1325–1338. doi:10.1016/S0140-6736(11)60555-2

Yamaguchi, B., Silva, A. Z., Araujo, L. B., Guimarães, A. T. B., & Israel, V. L. (2019). Psychomotor evaluation of children attending child education centers in the south of Brazil. *Early Child Development and Care*, *191*(11), 1707–1714. doi:10.1080/03004430.2019.1672165