Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Home-based balance training for children with cerebral palsy

Gwen Munsters
Gitte Peeters

Eerste deel van het scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Home-based balance training for children with cerebral palsy

Which home-based intervention affects the sitting or standing balance in children between 0 and 18 years with cerebral palsy?

- An individualized home-based exercise program applied for 2-10 years is effective to improve standing balance.
- Home-based robotic ankle rehabilitation applied for 6 weeks showed improvements of the Pediatric Balance Scale.
- No effective interventions for children with GMFCS-level IV-V were identified that improve sitting balance.

Munsters Gwen

Peeters Gitte

Promotor: Prof. Dr. P. Meyns

CONTEXT

This master's thesis part one can be situated in the research field of biomechanics and paediatric rehabilitation, particularly for children with cerebral palsy (CP).

Literature shows that children with CP have a reduced sitting and standing balance (Bigongiari et al., 2011; de Graaf-Peters et al., 2007; Schmit et al., 2016). The goal to improve balance should be considered in the rehabilitation of children with CP. The rehabilitation can be applied in a clinical and home-setting. Due the presence of the coronavirus disease (COVID-19), it is relevant to investigate interventions that can ensure social distance between the children and the therapist (Lasry et al., 2020). Home-based training is an effective way to combine rehabilitation and social distancing. There is evidence for using home based training in rehabilitation for children with CP. (novak et al., 2013). This could be due to the facts that home-based training can increase the amount of training (Tinderholt Myrhaug et al., 2015) and that the training can simulate the actual setting according to the principle of specificity of motor skill learning (Magill, R. A., & Anderson, 2013). Evidence of which home-based training can improve the balance of children with CP is relevant for physiotherapists.

This master's thesis is an isolated study that used a central format.

This is a duo master's thesis. The domain of research, namely 'balance of children with CP', is determined by promotor Prof. Dr. P. Meyns. The research question 'Which home-based intervention affects the sitting or standing balance in children between 0 and 18 years with CP?' was suggested by the two students. One student performed the literature search. The quality assessment was performed by two students separately and then combined afterwards. The data extraction was conducted by one student.

The two students developed a new research protocol, based on the recommendations of the systematic review.

PART 1 LITERATURE STUDY

1 ABSTRACT

Background: There is evidence for using home-based training in the rehabilitation for children with cerebral palsy (CP). This systematic review shows which home-based training is effective for sitting and/or standing balance in children between 0-18 year with CP.

Method: The literature search was performed on PubMed and Web of Science until April 2020. Articles were assessed on quality and data (design, participants, intervention, outcomes and results) was extracted. Included studies reported clinical and biomechanical sitting and standing balance outcomes.

Results: Four single-group design, one cross-over design, four comparative and one randomized controlled trial design were included. This review included 169 participants with spastic CP (n=163), dystonic (n=1), hypotonic (n=1) and at risk for CP (n=4). Six weeks robotic ankle training and 2-10 years individualized exercise training improved standing balance and PBS respectively for children with Gross Motor Function Classification System (GMFCS) level I-III. Electrical stimulation, MiTii games, strength training, Wii Fit and lower extremity functional training did not.

Discussion and conclusion: Home-based interventions can improve balance in children with CP. However evidence is necessary to optimize training modalities. Limited evidence for children with GMFCS-level IV-V is available.

Aim of the research: What is the influence of a one-year home-based MiTii training on balance in children between 7 and 18 years with CP with GMFCS-level I-III.

Operationalisation research question: Comparing a one-year home-based MiTii training with a one-year home-based robotic ankle training. PBS is evaluated at baseline, after the intervention and at six weeks follow-up to measure balance.

Important keywords: Cerebral palsy, Postural balance, Telerehabilitation

Abbreviations: Cerebral Palsy (CP); Gross Motor Function Classification System (GMFCS); Pediatric Balance Scale (PBS)

2 INTRODUCTION

Cerebral palsy (CP) is one of the most common childhood disabilities with a prevalence of 2.11 per 1000 live births (Oskoui et al., 2013). It is a movement disorder caused by a non-progressive injury to the developing brain (Wimalasundera & Stevenson, 2016). These children encounter difficulties at all levels of the framework of international classification of functioning, disability and health (ICF): body structure, activity and participation (Wimalasundera & Stevenson, 2016). Literature showed that children with CP have a reduced level of participation, especially for those with greater functional impairments (Imms, 2008). These functional impairments are mainly spasticity (Dietz & Sinkjaer, 2007), contractures, selective motor control and muscle weakness (Wimalasundera & Stevenson, 2016). CP does not only affect movements and posture but also limited sensation, perception, cognition, communication and behaviour (Bax et al., 2005). All these factors together can result in reduced balance. More specifically children with CP show difficulties in anticipatory and reactive sitting and standing balance (Bigongiari et al., 2011; de Graaf-Peters et al., 2007; Schmit et al., 2016). During the growth spurt of a child with CP, the combination of accelerated growth and the spasticity can result in increased limitations for daily functional activities and mobility. Therefore interventions during childhood are essential (Reubens & Silkwood-Sherer, 2016). A previous systematic review showed that the following interventions have a moderate level to improve the balance in children with CP; gross motor task training, hippotherapy, treadmill training with no body weight support (no-BWS), trunk-targeted training, and reactive balance training (Dewar et al., 2015). Neuroplastic changes in people with brain lesions can be induced when these interventions are more intensive and longer than traditional physical therapy sessions of 30 minutes/session for 3 days/week during a couple of months (Lang et al., 2009). One possibility to increase total amount of training outside physical therapy sessions is to suggest home-based training to patients. As home-based training can increase the amount of training, it is beneficial to improve neuroplastic changes (Tinderholt Myrhaug et al., 2015). According to the principle of specificity of motor skill learning, it is known that the transfer of learning is optimal when the training environment simulates the actual setting (Magill, R. A., & Anderson, 2013). Therefore a home-based training has potential to achieve better results for motor skill learning. Due to the presence of the coronavirus disease (COVID-19), it is relevant to investigate interventions that can ensure social distance between patients and their therapists. Physical distance and staying at home are especially critical to decrease the transmission of the virus due to the lack of a vaccine or treatment (Lasry et al., 2020). We can describe home-based training as therapeutic activities that the child performs with parental assistance in the home environment with the goal of achieving health outcomes (Novak et al., 2007). A systematic review that investigated the best available interventions based on 166 articles (including other systematic reviews) showed that (among other possible therapies, such as constraint-induced movement therapy) home-based programmes are effective and strongly recommended for children with CP (novak et al., 2013). Current systematic reviews that only focused on home-based training by children with CP investigated how to optimize engagement in interactive computer play-based motor therapy (Biddiss et al., 2019) and the effect on mobility levels of gait trainer use in home (Paleg & Livingstone, 2015). Despite the available literature concerning home-based interventions, there are no systematic reviews that investigated the effect of home-based training on balance. Therefore, the aim of this systematic review is to investigate which home-based training has the potential to affect the sitting and standing balance in children between 0-18 year with CP.

3 METHOD

This systematic review is reported following the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) statement (Moher et al., 2009).

3.1 Research question

The aim of this systematic review is to answer the following question: 'Which home-based intervention affects the sitting or standing balance in children between 0 and 18 years with CP?'

3.2 Literature search

The literature search was conducted on the databases PubMed and Web of Science.
Based on our PICO, the participants (P) must be children with CP between the age of 0 and 18 years, the intervention should me home-based (I) and the article includes outcome of sitting or standing balance (O). The following keywords were used in PubMed.

- Cerebral palsy (MeSH) OR Cerebral Palsy (Title/Abstract)

  AND
- Postural balance (MeSH) OR Balance (Title/Abstract) OR Posture (Title/Abstract) OR Stability (Title/Abstract) OR Equilibrium (Title/Abstract)

  AND
- Telerehabilitation (MeSH) OR Telerehabilitation (Title/Abstract) OR Home-based (Title/Abstract) OR Home (Title/Abstract) OR Domiciliary (Title/Abstract) OR Self-management (Title/Abstract)

  AND
- Rehabilitation (MeSH) OR Rehabilitation (Title/Abstract) OR Intervention (Title/Abstract) OR Therapy (Title/Abstract) OR Training (Title/Abstract)

The following keywords were used in the database Web of Science:

- Title =(Cerebral palsy)

  AND
- Topic=(Postural balance) OR Topic=(Balance) OR Topic=(Stability) OR Topic=(Posture) OR Topic=(Equilibrium)

  AND
- Topic=(Rehabilitation) OR Topic=(Intervention) OR Topic=(Therapy) OR Topic=(Training)

  AND

- Topic=(Home based) OR Topic=(Home) OR Topic=(Telerehabilitation) OR Topic=(Domiciliary) OR=(Self-management)

The search results were screened on title, abstract and if needed on full text.

3.3 Selection criteria

Articles were included by following criteria

- The participants are diagnosed with CP;
- The participants are aged between 0 and 18 years, valid for 3/4th of the sample;
- The article wields at least 1 outcome of balance (sitting and/or standing) to represent de effectiveness of their intervention;
- The article applies a home-based intervention, valid for 3/4th of the intervention;
- The article is published in Dutch or English.

Articles were excluded by following criteria

- The article applies a drug intervention;
- The article applies a surgical intervention;
- The article applies an intervention using only orthopaedic aids;
- The article design is a systematic review.

3.4 Quality assessment

The quality assessment of the included articles was executed using a checklist (Table 1). This checklist was compiled from two existing checklists. The checklist was primarily based on the checklist 'Evaluation criteria for RCT' [Dutch: Beoordelingscriteria voor een RCT] (Scholten, 2018) However, this checklist did not evaluate the selection of the participants. Therefore we added one question from another checklist 'Evaluation criteria for research concerning progrnosis [Dutch: Beoordelingscriteria voor een onderzoek over prognose] (Scholten et al., 2013).

Table 1 Checklist for quality assessment

	+	-	N/A	value
1. Was the selection of the participants for the study valid? (selection bias)				1
2. Is for a sufficient proportion of all included participants a full follow-up available? (> 80%)				2
If not: is selective loss-to-follow-up sufficiently excluded?				2
3. Was the allocation of the participant randomised? (allocation bias)				2
4. Is/are the group(s) adequately defined (selection criteria, demographic data)?				2
5. Was the person who included participant blinded?				2
6. Were the participants and the therapists blinded for the intervention? (performance bias)				1
7. Were the assessors blinded for the intervention? (detection bias)				2
8. Were the groups similar at baseline? (attrition bias)				2
If not: is this corrected in the analyses?				2
9. Were all included participants analysed in the group they were randomly allocated to?				1
10. Have the groups been treated equally, apart from the intervention?				2
11. Is selective publication of data sufficiently excluded? (reporting bias)				2
12. Is conflict of interest excluded?				2
Level of evidence				

N/A, not applicable or not available

The researchers indicate whether the criterion has been met in the column with the plus sign, if the criterion has not been met, they use the column with the minus sign. In case the criterion is not applicable to the study, this was marked in the N/A-column. Subsequently, this criterion was not included in the total score. In case that the criterion was not mentioned in the text, this was indicated in the N/A-column with a question mark. In the total score, a question mark is counted as zero. Each score of the different criteria was weighted according to its importance. Criteria 1, 6 and 9 were given a importance-value of one and the other criteria an importance-value of two. The accessibility of children with CP is limited, giving more chance of selection bias, therefore criterion 1 was given a lower importance-value. Furthermore, it is almost impossible for the participants and therapists to be blinded for a therapeutic intervention, hence the lower importance-value for criterion 6. Lastly criterion 9 was also given a lower importance-value, home-based interventions can induce practical problems (e.g. integration family life, connection to the internet) that could be solved by changing to the control group. Altogether, these values were used to calculate a total score per article. This total score was eventually expressed as a percentage. The assessment of quality was independently conducted by two researchers. Afterwards, the results were combined into the final assessment of quality. The level of evidence will be displayed in the last column, based on the guideline from the National Health and Medical Research Council (NHMRC) (Coleman et al., 2008).

Based on the quality checklist, possible risks of bias were detected for each individual article. Question 1, 3, 6, 7, 8 and 11 were linked to selection bias, allocation bias, performance bias, detection bias, attrition bias and reporting bias, respectively.

3.5 Data-extraction

From the included studies, the following data was inventoried: the reference of the study, study design, participants, intervention, outcomes and results. Following information from the participants was inventoried: age, the type of CP and the GMFCS-score. Only the tests for the assessment of sitting or standing balance were included, as well as the timing and the results of these tests.

4 RESULTS

4.1 Results study selection

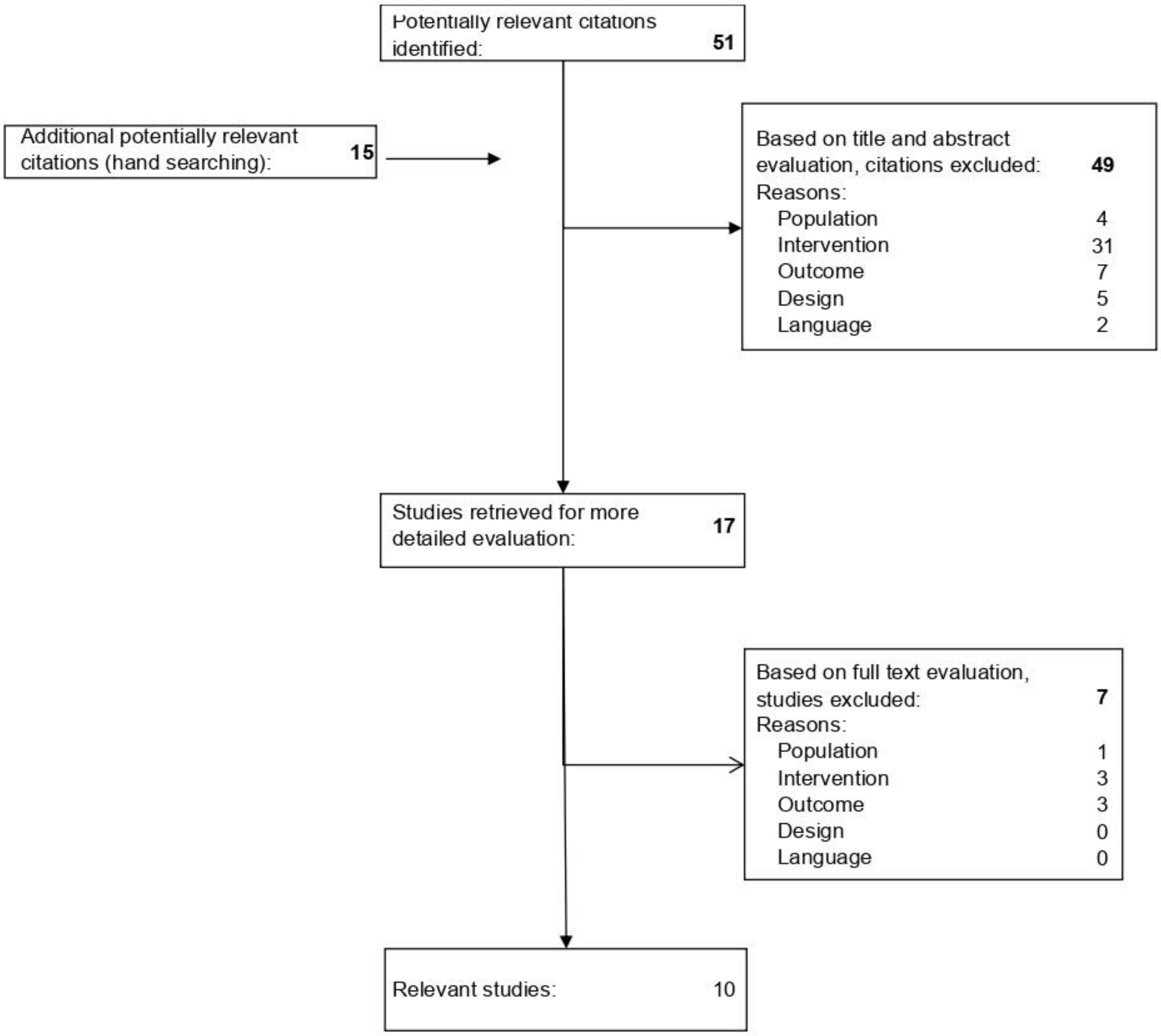
The literature search on 13 January 2020 performed on Pubmed, yielded 37 hits (Table 2). The search performed on Web of Science (WoS) yielded 39 hits. An update was performed on 4 April 2020 to guarantee the inclusion of recently published articles.

Table 2 Results literature search

	Search terms	# hits PubMed	# hits WoS
#1	Cerebral palsy (MeSH) OR Cerebral palsy (Title/Abstract)	27 117	30 580
#2	Postural balance (MeSH) OR Balance (Title/Abstract) OR Posture (Title/Abstract) OR Stability (Title/Abstract) OR Equilibrium (Title/Abstract)	780 086	2 879 887
#3	Telerehabilitation (MeSH) OR Telerehabilitation (Title/Abstract) OR Home-based (Title/Abstract) OR Home (Title/Abstract) OR Domiciliary (Title/Abstract) OR Self-management (Title/Abstract)	235 661	438 316
#4	Rehabilitation (MeSH) OR Rehabilitation (Title/Abstract) OR Intervention (Title/Abstract) OR Therapy (Title/Abstract) OR Training (Title/Abstract)	3 019 582	4 135 899
#5	#1 and #2 and #3 and #4	37	39

The hits on Pubmed and WoS showed an overlap of 25 articles. Of the remaining 51 articles, an overview of the study selection is shown in a flowchart (Figure 1). The articles were first screened on title and abstract. This resulted in the exclusion of 34 articles. The remaining 17 articles were screened on full text, this resulted in the exclusion of another 7 articles. The researchers also conducted a manual search via the reference lists of the included articles. This manual search resulted in no extra inclusion of other articles.

Figure 1 Flowchart study selection



The main reason of exclusion of articles was the type of intervention (Table 3 in appendix). The articles were excluded if the intervention was not home-based or if the intervention was orthopaedic, surgical or medical. A total of 34 articles were excluded based on the type of intervention. A second reason for exclusion is the outcome. The articles had to contain at least one outcome measure for sitting or standing balance to represent the effectiveness of their intervention. Ten articles were excluded based on the outcome. Five systematic reviews were excluded because of their study design. Four articles were excluded due to the fact that the participants were not children diagnosed with CP between the ages of 0 and 18 years. Lastly, two articles were not published in English or Dutch, therefore they were also excluded.

4.2 Results quality assessment

None of the studies were excluded based on the quality assessment (Table 4). Four articles had a total score below 50%, namely (Bilde et al., 2011) with 25%, (K. Chen et al., 2014) with 43%, (K. Chen et al., 2016) with 39% and (Lorentzen et al., 2015) with 35%. Firstly, the three articles with the lowest total score did not have a total follow-up of at least 80% of the included participants. In addition a selective loss-to-follow-up was not sufficiently excluded. Secondly, there was no blinding of the assessor, or it was not mentioned in the text, in all the articles. Lastly, selective publication could not be excluded for both (Bilde et al., 2011) and (Lorentzen et al., 2015). Both studies published different numbers of outcome measures with each test they conducted, without an explanation.

Four articles have level of evidence IV according to the National Health and Medical Research Council (NHMRC) (Coleman et al., 2008) these articles were single group studies (Bilde et al., 2011; K. Chen et al., 2014; Ko et al., 2018; McBurney et al., 2003). Ramstrand & Lygnegård used a randomized cross-over study, which corresponds to a level of evidence III-3. Other four articles have level of evidence III-2, they used a comparative design, however they did not meet the criteria required for a randomized controlled trial (K. Chen et al., 2016; Harbourne et al., 2010; Jeng et al., 2013; Lorentzen et al., 2015). Only one article has level of evidence II, a randomized controlled trial design was used (Surana et al., 2019).

Table 4 Results quality assessment

	1	2a	2b	3	4	5	6	7	8a	8b	9	10	11	12	Tot. (…/…)	Tot. (…%)	LoE
(Bilde et al., 2011)	?	-	-	/	+	?	-	?	/		/	/	-	+	4/16	25%	IV
(K. Chen et al., 2014)	?	+		/	+	-	-	?	/		/	/	+	-	6/14	43%	IV
(K. Chen et al., 2016)	-	-	-	+	+	-	-	-	+		+	-	+	?	9/23	39%	III-2
(Harbourne et al., 2010)	?	+		+	+	?	-	+	+		+	+	+	?	14/22	64%	III-2
(Jeng et al., 2013)	-	+		/	+	?	-	?	+		+	/	+	/	9/15	60%	III-2
(Ko et al., 2018)	+	+		/	+	?	-	+	/		/	/	+	+	11/14	79%	IV
(Lorentzen et al., 2015)	?	-	-	-	+	-	-	-	+		+	+	-	+	8/23	35%	III-2
(McBurney et al., 2003)	?	+		/	+	?	-	+	/		/	/	+	?	8/14	57%	IV
(Ramstrand & Lygnegård, 2012)	+	-	+	+	+	?	-	?	+		+	-	+	+	14/23	61%	III-3
(Surana et al., 2019)	+	-	+	+	+	?	-	-	+		+	+	+	+	16/23	70%	II

/, not applicable; LoE, Level of Evidence

In table 5 an overview of the assessment of risk of bias per article is represented. Seven articles have a risk of selection bias, in five of these articles the researchers did not present how they selected their participants. There was no risk of allocation bias in the articles. In all the articles the participants and therapists were not blinded for the intervention, this resulted in risk of performance bias. In only three articles blinding of assessors was reported, in four other articles the blinding was not mentioned. Risk of attrition bias was not detected in the individual articles. In only two articles there was a risk of reporting bias.

Table 5 Results detection risk of bias

	Selection bias	Allocation bias	Performance bias	Detection bias	Attrition bias	Reporting bias
(Bilde et al., 2011)	X		X	X	/	X
(K. Chen et al., 2014)	X		X	X	/	
(K. Chen et al., 2016)	X		X	X		
(Harbourne et al., 2010)	X		X			
(Jeng et al., 2013)	X		X	X		
(Ko et al., 2018)			X		/	
(Lorentzen et al., 2015)	X		X	X		X
(McBurney et al., 2003)	X		X		/	
(Ramstrand & Lygnegård, 2012)			X	X		
(Surana et al., 2019)			X	X		

/, not applicable

4.3 Results data-extraction

Ten articles were included. Four articles with level of evidence IV (Bilde et al., 2011; K. Chen et al., 2014; Ko et al., 2018; McBurney et al., 2003), one article with level of evidence III-3 (Ramstrand & Lygnegård, 2012), four articles with level of evidence III-2 (K. Chen et al., 2016; Harbourne et al., 2010; Jeng et al., 2013; Lorentzen et al., 2015) and one article with level of evidence II (Surana et al., 2019) were included. In total, 169 participants were included in this systematic review. The sample size ranged from 9 to 41 participants. The participants have an average age of five months to 17 years. All participants were diagnosed with CP, most commonly with spastic CP (n=163), however some dystonic (n=1) and hypotonic (n=1) CP (Ko et al., 2018) and children at risk for CP (n=4) (Harbourne et al., 2010) were included too. The included participants had a GMFCS-level ≤ III (n=152). However two articles included participants with GMFCS-level > III (n=17) (Harbourne et al., 2010; Ko et al., 2018). The included articles used a variety of different home-based interventions. We can discern six types of home-based interventions. (1) Move it to improve it (MiTii) was investigated in two articles (Bilde et al., 2011) and (Lorentzen et al., 2015). MiTii is an online training system that requires the child to analyse visual information, solve a cognitive problem and respond with a motor act. (2) Tele-assisted home robotic rehabilitation intervention on the impaired ankle was used in two articles (K. Chen et al., 2014) and (K. Chen et al., 2016). The other investigated interventions were (3) lateral electrical surface stimulation (LESS) (Ko et al., 2018), (4) Wii Fit balance games (Ramstrand & Lygnegård, 2012), (5) lower extremity intensive functional training (LIFT) (Surana et al., 2019) and (6) home-based exercise programs (Harbourne et al., 2010; Jeng et al., 2013; McBurney et al., 2003) (Strength training, for infants and individualized program consisting of endurance, strength, flexibility , agility and balance training). The duration of intervention ranged from six weeks to twenty weeks, except for one article that had an average duration of 5.7 years (Jeng et al., 2013). Training intensity varied from 30 minutes three times per week up to one hour twice a day. The result of the data-extraction are summarized in table 6.

Sitting balance

In the included articles, sitting balance was measured with centre of pressure data (CoP), trunk control measurement scale (TCMS) and the sitting score of the gross motor function measurement - 88 (GMFM-88). Harbourne et al. used CoP data, they compared an eight week home-program performed by the caregiver of the infant with a perceptual-motor intervention (PMI) in an outpatient setting. They reported a significant difference between the home-program group and PMI for the velocity and regularity of the CoP. The home-program group had a lower velocity and greater regularity of the CoP after the home-program. Ko et al. evaluated the effect of LESS at home on scoliosis and balance in children with CP and scoliosis using the TCMS and GMFM-88. The TCMS and the sitting score of GMFM-88 did not show significant intragroup improvement. However the article found evidence that the sitting score of the GMFM-88 was correlated with the stimulation intensity of LESS between baseline and three months after the intervention.

Standing balance

In the included articles, standing balance was measured with the one leg standing test (OLST), Romberg 30 seconds test with eyes open, specifics balance tests on a force plate and a depth-interview for a qualitative study. The OLST was used in two articles. In one article (Jeng et al., 2013) the OLST on the non-dominant leg showed significant improvement after an individualized home-based exercise program (consisting of endurance, strength, flexibility , agility and balance training) with a mean duration of 5,7 years. It also showed significant better results compared with a group of children without exercise training. Contrarily, the article by (Surana et al., 2019) showed no significant intergroup difference after a nine week lower extremity intensive functional training (LIFT) at home compared with hand-arm bimanual intensive therapy (HABIT). The Romberg 30 seconds test showed no statistically significant changes between baseline and after a 20 weeks Move it to improve it (MiTii) intervention in both articles (Bilde et al., 2011; Lorentzen et al., 2015). Additionally Lorentzen et al. found no significantly differences between the 20 weeks MiTii training and a control group without any intervention on the Romberg 30 seconds test. Furthermore Ramstrand et al. did not show significant improvement of all tests on the force plate after 5 weeks playing balance games on the Wii Fit. The qualitative article by (McBurney et al., 2003) investigated a home-based strength intervention with a depth-interview. It showed that one child of nine had the perception of not swaying as much after the intervention, the perception of balance was not mentioned by the other children.

PBS

The PBS was used in two articles as outcome measurement for balance.(K. Chen et al., 2014, 2016) Both articles investigated the same intervention, namely a 6 week tele-assisted home robotic rehabilitation intervention on the impaired ankle. The first article had a single group design (K. Chen et al., 2014). The second article compared the home-based robotic rehabilitation with a laboratory-based robotic rehabilitation (K. Chen et al., 2016). The PBS score improved significantly between baseline and immediately after the intervention for all groups of both articles. No differences were found between the home-based and laboratory group. The improvements at the six week follow-up were retained in the first article (K. Chen et al., 2014) and in the second article (K. Chen et al., 2016) only the home-based group retained their improvements.

Table 6 Results data-extraction

Reference	Design	Sample	Intervention	Outcomes	Results
(Bilde et al., 2011)	Single group pilot study	▪ N = 9 ▪ Spastic CP ▪ GMFCS-level I-II ▪ 9-13 years	▪ Home-training with MiTii. The child has to analyse visual information, solve a cognitive problem and respond with a motor act ▪ 30 min a session ▪ 1 session each day ▪ 20 week period	▪ Romberg 30 seconds, eyes open ▪ Evaluated at baseline and immediately after the intervention	▪ The Romberg test showed no statistically significant changes between baseline and after the intervention
(K. Chen et al., 2014)	Single group study	▪ N = 23 ▪ Spastic CP ▪ Hemiplegia n = 12 Diplegia n = 11 ▪ GMFCS-level < III ▪ 5-17 years	▪ Tele-assisted home robotic rehabilitation intervention on the impaired ankle ▪ 18 sessions ▪ 6 week period	▪ PBS ▪ Evaluated at baseline, immediately after intervention and at six weeks follow-up	▪ PBS score improved significantly ▪ The difference between pre- to post-evaluation was significant ▪ The improvement was retained at the follow-up

(K. Chen et al., 2016)	Pilot randomized comparative study	▪ N = 41 ▪ Spastic CP ▪ Hemiplegia n = 21 Diplegia n = 20 ▪ GMFCS-level I-III ▪ 9.7 ±4.4 years	▪ Home-based or laboratory-based intervention performed using a portable rehabilitation robot for the ankle ▪ 10 min passive stretching, 20 min active movement, 10 min of passive stretching of the ankle ▪ 18 sessions ▪ 6 week period	▪ PBS ▪ Evaluated at baseline, immediately after intervention and at six weeks follow-up	▪ Both groups demonstrated significant improvement in the PBS between baseline and after the intervention ▪ The improvement in PBS was retained at the follow-up only for the home-based group
(Harbourne et al., 2010)	Randomized longitudinal study	▪ N = 30 ▪ Delayed development and at risk for CP (n=4) or diagnosed with CP	HP ▪ Consisted of daily routine, holding the infant so the trunk support was reduced to practice trunk	▪ CoP data analysed using linear and nonlinear tools Intervention group	HP ▪ RMS AP: no effect of time, no group*time interaction

		▪ GMFCS-level I-IV ▪ 14.9 ±5 months Control group ▪ N = 15 ▪ Typical development infants ▪ 5 ±0.5 months	control and sitting skills ▪ 1 home visit session each week ▪ 8 week period PMI ▪ Self-initiated, goal-directed movements for functional action were emphasized ▪ 50 min a session ▪ 2 sessions each week ▪ 8 week period	▪ Evaluated baseline and one month after intervention Control group ▪ Evaluated around 5 months of age and three months later	▪ RMS ML: significant effect of time, it decreased between pre and post intervention, no group*time interaction effect ▪ Velocity: no effect of time, significant group*time effect post intervention, HP lower than PMI ▪ ApEn in AP: significant effect of time, it increased ▪ ApEn in ML: no effect of time, significant group*time effect post intervention,

					lower value, greater regularity PMI ▪ RMS AP: no effect of time, no group*time interaction ▪ RMS ML: significant effect of time, it decreased between pre and post intervention, no group*time interaction effect ▪ Velocity: no effect of time, significant group*time effect post intervention, PMI higher than HP

					▪ ApEn in AP: significant effect of time, it increased ▪ ApEn in ML: no effect of time significant group*time effect postintervention, higher value, lower regularity
(Jeng et al., 2013)	Follow-up non-randomized control study	▪ N = 21 ▪ Spastic CP ▪ Diplegia n = 12 Hemiplegia n = 8 Ataxia n = 1 ▪ 16.6 ±3.9 years	▪ Individualized home-based exercise program or no exercise training ▪ Training duration mean 5,7 years, range of 2-10 years	▪ OLST-D and OLST-ND flexing other knee at 90°, eyes opened ▪ Evaluated after a home-based program in 2003 and 10	▪ OLST-ND increased significant between 2003 and 2013 for the intervention group ▪ OLST-ND significant difference between intervention and control group at the present,

				years later in 2013	intervention group scores higher
(Ko et al., 2018)	Single group pilot study	▪ N = 11 ▪ CP and scoliosis ▪ Spastic n = 9 Dystonic n = 1 Hypotonic n = 1 ▪ GMFCS level IV-V ▪ 3-15 years	▪ LESS on the convex side of the trunk curve ▪ 1 hour a session ▪ 2 sessions each day ▪ 3 months period	▪ TCMS ▪ Sitting score of GMFM-88 ▪ Evaluated 3 months before, baseline, 1 month after and 3 months after LESS	▪ No significant changes in TCMS and GMFM-88 between baseline and 1 month after the intervention ▪ The stimulation intensity is significant correlated with improvement of GMFM-88 between baseline and '3 months after' also between '1 month after' and '3 months after'

					▪ The stimulation intensity is not correlated with TCMS
(Lorentzen et al., 2015)	Non-randomised control study	▪ N = 34 ▪ Spastic CP ▪ GMFCS level I-II ▪ 10.9 ±2.4 years	▪ Home-training with MiTii The child has to analyse visual information, solve a cognitive problem and respond with a motor act ▪ 30 min a session ▪ One session each day ▪ 20 week period	▪ Romberg 30 seconds, eyes open Intervention group ▪ Evaluated at baseline, immediately after and 12 weeks after intervention Control group ▪ Evaluated at baseline and immediately after the intervention	▪ No significant difference between intervention and control group and no significant difference between pre and post intervention C90, the velocity of sway and the total trace length

(McBurney et al., 2003)	Single group qualitative study	▪ N = 11 ▪ Spastic CP ▪ GMFCS-level I-III ▪ 12.7 ±2.8 years	▪ Home-based strength-intervention, three exercises, 8-10 repetitions each exercise ▪ 3 sessions each week ▪ 6 week period	▪ Semi-structured depth-interview with the parents and child separate ▪ Evaluated after the intervention	▪ Perception that balance in standing had improved
(Ramstrand & Lygnegård, 2012)	Randomized cross-over study	▪ N = 12 ▪ Spastic CP ▪ GMFCS-level I-II ▪ 8-17 years	▪ Home-based Wii Fit balance games ▪ 30 min a session ▪ 5 sessions each week ▪ 5 week period	▪ Balance test using PRO Balance Master force plate ▪ MSot, stand still for 20 sec while exposed to four sensory conditions ▪ Reactive balance, investigating	MSot ▪ No significant difference between testing occasions for the mean velocity of the CoP, total displacement of the CoP in AP and ML direction ▪ When standing on an unstable surface, eyes open, 6 falls were recorded at

				the latency of response in low leg musculature after external perturbation ▪ Rhythmic weight shift, control position of CoP displayed on the screen, on-axis distance and off axis distance ▪ Evaluated at baseline, after 5 weeks of Wii Fit and after 5 weeks of no Wii Fit	baseline and 1 after 5 weeks Wii Fit, no falls after 5 weeks without Wii Fit ▪ When standing on an unstable surface with eyes closed, 26 falls were recorded at baseline, 18 falls after 5 weeks Wii Fit, 20 falls after 5 weeks without Wii Fit Reactive balance ▪ No significant difference in onset latency of lower leg muscles in upward or downward direction between testing occasions

					Rhythmic weight shift ▪ No sign difference of control in the AP or ML direction between testing occasions
(Surana et al., 2019)	Randomized controlled study	▪ N = 24 ▪ Unilateral spastic CP ▪ GMFCS-level I-II ▪ 5.5 ±2.8 years	▪ Intervention group home-setting LIFT 4 strengthening, 2 balance and 2 coordination activities per session ▪ Control group home-setting H-HABIT bimanual activities ▪ 2 hours a session ▪ 5 days each week ▪ 9 week period	▪ OLST-ND ▪ Evaluated at baseline, immediately after and 6 months follow-up	▪ LIFT group made greater improvements in OLST-ND between the pre-test and post-test relative to H-HABIT, but no significant difference

MiTii, Move It To Improve It; HP, home program; PMI, perceptual-motor intervention; CoP, Centre of pressure; RMS, root means square; AP, anterior-posterior; ML, medial-lateral, ApEn, regularity of the centre of pressure; OLST-D, one-leg standing test dominant leg; OLST-ND, one-leg standing test non dominant leg; LESS, lateral electrical surface stimulation; TCMS, trunk control measurement scale; GMFM-88, gross motor function measure; C90, the area that the centre of gravity was maintained for 90% of the time; Msot, modified sensory organisation test; LIFT, Lower extremity intensive functional training; H-HABIT, Hand-Arm bimanual intensive therapy

5 DISCUSSION

5.1 Reflection on quality of the studies

The articles showed a great diversity in quality, ranging from 25% to 79%. We included four articles with level of evidence IV, their quality score ranged from 25% to 79%. Only one article with level III-3 was included, with a total score of 61%. Four articles with level of evidence III-2 were included, with total quality score ranging from 35% to 64%. Only one article with level of evidence II was included, with a total quality score of 70%. Therefore the highest scoring article had a single group design (Ko et al., 2018). However the second highest scoring article was a randomized controlled trial (Surana et al., 2019). The included articles generally have a low level of evidence, however they do have moderate to high quality.

A total of seven articles showed a risk of selection bias, moreover five articles did not report how they selected their participants (Bilde et al., 2011; K. Chen et al., 2014; Harbourne et al., 2010; Lorentzen et al., 2015; McBurney et al., 2003). However this bias might be difficult to overcome with the population of children with CP, therefore this bias was deemed less important. All included articles have a risk of performance bias, because blinding of the therapists and the participants is impossible in a therapeutic intervention. This type of intervention should not interfere with blinding of the assessor, however only three articles reported blinding of the assessor (Harbourne et al., 2010; Ko et al., 2018; McBurney et al., 2003). Generally most articles did not show great risks of bias. With some precaution we can draw conclusions from these articles.

5.2 Reflection on findings as a function of the research question

It is possible to use home-based training for improving balance in children with CP, this however depends on the different modalities of the interventions. Three articles showed significant improvement of balance in children with CP (K. Chen et al., 2014, 2016; Jeng et al., 2013). Chen et al (2014, 2016) investigated home-based robotic ankle training for children with CP with GMFCS-level I-III. Jeng et al investigated a long-term individualized home-based exercise program for children with spastic CP. The other seven articles showed no significant results (Bilde et al., 2011; Harbourne et al., 2010; Ko et al., 2018; Lorentzen et al., 2015; McBurney et al., 2003; Ramstrand & Lygnegård, 2012; Surana et al., 2019). These articles included different interventions; MiTii, home exercise program, LESS, Wii Fit balance games and LIFT. We did not report a specific level of GMFCS in the inclusion criteria, to include the entire population of children (0-18y) with CP. None of the articles, however, included participants with all levels of GMFCS, this due to the fact that it is difficult to conduct an intervention that can be applied to all GMFCS-levels.

Three articles investigated the effectiveness of home-based virtual reality games on balance in children with CP (Bilde et al., 2011; Lorentzen et al., 2015; Ramstrand & Lygnegård, 2012). None of these articles showed significant improvements in balance. This finding is inconsistent with a meta-analysis that showed that virtual reality games (not necessarily in a home-based context) play a positive role in the improvement of balance of children with CP (Wu et al., 2019). Almost all the interventions included in the meta-analysis from Wu et al. were performed in the presence of a therapist, in a clinical setting. However the interventions included in this review were performed home-based without supervision from a therapist. This indicates that the addition of supervision in the home-based virtual reality games, for example through the internet, could be beneficial for the effectiveness of the interventions.

An exercise training performed in a home setting was applied in three articles (Jeng et al., 2013; McBurney et al., 2003; Surana et al., 2019). These interventions consisted mainly of lower extremity strength exercises and balance exercises. It seems that interventions with a short duration have less impact on balance in children with CP. Firstly, Surana et al. did not find significant changes in balance after a nine week period of Lower-Extremity Functional Training (LIFT). Additionally, in the qualitative analysis by Mcburney et al. only one participant reported standing balance improvement after a six week intervention. There is no reported balance data from the other ten participants. On the other hand Jeng et al. showed a significant improvement in balance after an intervention between two and ten years, this could indicate that a longer duration of intervention is needed to improve balance. Jeng et al. also showed that these improvements retained after a ten year follow-up. This may suggest a second benefit of a long duration of intervention, namely a long-term effect on balance of children with CP.

Two articles investigated the use of a portable rehabilitation robot for ankle impairment. Both articles reported significant improvements of balance (K. Chen et al., 2014, 2016). Both interventions were conducted for a six week period, containing 18 sessions. This indicates that the portable rehabilitation robot could be used for improving balance in a home setting. Even though the findings for exercise training indicate a longer training duration is necessary for improvement of balance, this is not applicable for home-based robotic ankle training, since this intervention showed significant improvements after only six weeks. Improvements were present in balance and active range of motion, this could indicate a possible correlation. These improvements could be explained by the inclusion of passive stretching and the specific focus on one joint (ankle) in this type of interventions. Further these two articles were the only articles that used the Pediatric Balance Scale, that evaluates different components of balance, as outcome measure. In the other included articles usually only one task of balance was assessed. It should be noted that the use of a portable rehabilitation robot can be more expensive than an exercise program.

Only two articles included participants with a high GMFCS-level (IV-V). Ko et al showed no significant improvements of balance after lateral electrical surface stimulation (LESS). However the stimulation intensity does show a significant correlation with changes of GMFM-88. More research on the exact stimulation intensity is necessary. Harbourne et al. showed that a home program intervention which targeted sitting balance, can change sitting behaviour significantly. The home group showed lower velocity and greater regularity of CoP, this indicates less explorative behaviour and a maintenance of stability that is not dynamic. This could be due to the fact that the therapy is integrated into daily routines applied by the main caregiver, therefore the infant is less exposed to explorative environments which require balance.

5.3 Reflection on the strengths and limitations of the literature search

The researchers report a number of limitations. Only two databases were used to include articles for their review. Secondly the selection based on the abstract was only performed by one researcher.

There were also strengths reported by the researchers. A sufficient amount of synonyms of the keywords were added to the search strategy based on the PICO. This search strategy was once again conducted recently to include all recent articles. Further the researchers applied a detailed assessment of quality with detection of risk of bias. This assessment was performed by the two researchers individually, afterwards the results were combined.

5.4 Recommendations for future studies

A home-based individualized exercise program with duration between two and ten years showed significant improvements on balance in children with CP (K. Chen et al., 2014, 2016). Future studies should focus on the recommended training modalities (e.g. session/intervention duration, frequency) to optimize the effect on balance. Furthermore three articles included home-based virtual reality games, they showed no significant results (Bilde et al., 2011; Lorentzen et al., 2015; Ramstrand & Lygnegård, 2012). We suggest to investigate the addition of supervision in future studies. Lateral electrical surface stimulation (LESS) showed no significant changes in balance, however the stimulation intensity was significantly correlated with improvement of GMFM-88 (Ko et al., 2018). Research on the recommended stimulation intensity to optimize balance is necessary. In general limited effective home-based intervention in children with CP with GMFCS-level IV-V were identified that improve sitting balance. We suggest to investigate home-based interventions that could be applied for GMFCS level IV-V.

6 CONCLUSION

This systematic review investigated which home-based intervention can affect the sitting or standing balance in children between 0 and 18 years with CP. The results indicate that an individualized long-term training is effective to improve standing balance in children with CP. As well as a home based robotic ankle training shows improvements of the PBS in children with CP with GMFCS-level I-III. However more evidence about training modalities to optimize the effects on balance is necessary. In addition there is a lack of effective interventions for children with GMFCS-level IV-V to improve balance significantly.

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8 APPENDIX

Table 3 Overview of reason for exclusion

Reference	Incl.	Excl.		RFE
		T+A	FT	
AlSaif, A. A., & Alsenany, S. (2015). Effects of interactive games on motor performance in children with spastic cerebral palsy. Journal of Physical Therapy Science, 27(6), 2001–2003. https://doi.org/10.1589/jpts.27.2001		x		Intervention
Antle, B. J., Mills, W., Steele, C., Kalnins, I. V., & Rossen, B. (2008). An exploratory study of parents' approaches to health promotion in families of adolescents with physical disabilities. Child: Care, Health and Development, 34(2), 185–193. https://doi.org/10.1111/j.1365-2214.2007.00782.x		X		Intervention
Berg, K. (1970). Effect of physical training of school children with cerebral palsy. Acta Paediatrica Scandinavica, Suppl 204: 227		X		Intervention
Berker, A. N., & Yalçin, M. S. (2008). Cerebral palsy: Orthopedic Aspects and Rehabilitation. Pediatric Clinics of North America, 55(5), 1209–1225. https://doi.org/10.1016/j.pcl.2008.07.011		X		Intervention
Bilde, P. E., Kliim-Due, M., Rasmussen, B., Petersen, L. Z., Petersen, T. H., & Nielsen, J. B. (2011). Individualized, home-based interactive training of cerebral palsy children delivered through the Internet. BMC Neurology, 11(1), 32. https://doi.org/10.1186/1471-2377-11-32	X			
Bloswick, D. S., Brown, D., King, E. M., Howell, G., & Gooch, J. R. (1996). Testing and evaluation of a hip extensor tricycle for children with cerebral palsy. Disability and Rehabilitation, 18(3), 130–136. https://doi.org/10.3109/09638289609166030			X	Outcome
Bonnechère, B., Jansen, B., Omelina, L., & Van Sint Jan, S. (2016). The use of commercial video games in rehabilitation:		X		

A systematic review. International Journal of Rehabilitation Research, 39(4), 277–290. https://doi.org/10.1097/MRR.0000000000000190				
Bonnechère, B., Omelina, L., Jansen, B., & Van Sint Jan, S. (2017). Balance improvement after physical therapy training using specially developed serious games for cerebral palsy children: preliminary results. Disability and Rehabilitation, 39(4), 403–406. https://doi.org/10.3109/09638288.2015.1073373			X	Intervention
Bryant, E., Pountney, T., Williams, H., & Edelman, N. (2013). Can a six-week exercise intervention improve gross motor function for non-ambulant children with cerebral palsy?. A pilot randomized control trial. Clinical Rehabilitation, 27(2), 150–159.		X		Intervention
Bumin, G., & Kayihan, H. (2001). Effectiveness of two different sensory- integration programmes for children with spastic diplegic cerebral palsy. Disability and Rehabilitation, 23(9), 394–399. https://doi.org/10.1080/09638280010008843			X	Intervention
Butler, E. E., Steele, K. M., Torburn, L., Gamble, J. G., & Rose, J. (2016). Clinical motion analyses over eight consecutive years in a child with crouch gait: A case report. Journal of Medical Case Reports, 10(1), 1–10. https://doi.org/10.1186/s13256-016-0920-9		X		intervention
Butler, P. B. (1998). A preliminary report on the effectiveness of trunk targeting in achieving independent sitting balance in children with cerebral palsy. Clinical Rehabilitation, 12(4), 281–293. https://doi.org/10.1191/026921598667577442		X		Intervention
Chen, K., Ren, Y., Gaebler-Spira, D., & Zhang, L. Q. (2014). Home-based tele-assisted robotic rehabilitation of joint impairments in children with CP. 2014 36th Annual International Conference of the IEEE Engineering in Medicine	X			

and Biology Society, EMBC 2014, 5288–5291. https://doi.org/10.1109/EMBC.2014.6944819				
Chen, K., Wu, Y. N., Ren, Y., Liu, L., Gaebler-Spira, D., Tankard, K., Lee, J., Song, W., Wang, M., & Zhang, L. Q. (2016). Home-Based Versus Laboratory-Based Robotic Ankle Training for Children With cerebral palsy: A Pilot Randomized Comparative Trial. Archives of Physical Medicine and Rehabilitation, 97(8), 1237–1243. https://doi.org/10.1016/j.apmr.2016.01.029	X			
Chiu, H. C., Ada, L., & Lee, S. Da. (2018). Balance and mobility training at home using Wii Fit in children with cerebral palsy: A feasibility study. BMJ Open, 8(5), 1–8. https://doi.org/10.1136/bmjopen-2017-019624			X	Outcome
Crichton, J. (1998). Balancing restriction and freedom in the care of people with intellectual disability. Journal of Intellectual Disability Research, 42(2), 189–195. https://doi.org/10.1046/j.1365-2788.1998.00117.x		X		Intervention
Damiano DL, Vaughan C, Abel MF. (1995) Muscle response to heavy resistance exercise in children with spastic cerebral palsy. Dev Med Child Neurol 37: 731–739		X		Outcome
Danielsson AJ, Hasserius R, Ohlin A, et al. Body appearance and quality of life in adult patients with adolescent idiopathic scoliosis treated with a brace or under observation alone during adolescence. Spine (Phila Pa 1976). 2012;37:755–762		X		Outcome
De Oliveira, J. M., Fernandes, R. C. G., Pinto, C. S., Pinheiro, P. R., Ribeiro, S., & De Albuquerque, V. H. C. (2016). Novel virtual environment for alternative treatment of children with cerebral palsy. Computational Intelligence and Neuroscience, 2016. https://doi.org/10.1155/2016/8984379		X		Outcome
Deutsch JE, Borbely M, Filler J, Huhn K, Guarrera-Bowlby P. Use of a low-cost, commercially available gaming console		X		Intervention

(Wii) for rehabilitation of an adolescent with cerebral palsy. Phys Ther. 2008;88:1196–207				
Dewar, R., Claus, A. P., Tucker, K., Ware, R. S., & Johnston, L. M. (2019). Reproducibility of the Kids-BESTest and the Kids-Mini-BESTest for Children With cerebral palsy. Archives of Physical Medicine and Rehabilitation, 100(4), 695–702. https://doi.org/10.1016/j.apmr.2018.12.021		X		Intervention
Dodd KJ, Taylor NF, Graham HK. A randomized clinical trial of strength training in young people with cerebral palsy. Dev Med Child Neurol. 2003;45:652–7.		X		Intervention
Drewes, E., Driscoll, M., Blyum, L., & Vincentz, D. (2016). The Effects of a Home-Based Connective Tissue Targeting Therapy on Hip Development in Children With cerebral palsy: Six Case Reports. Explore: The Journal of Science and Healing, 12(4), 268–276. https://doi.org/10.1016/j.explore.2016.04.004		X		Intervention
Eckerson LF, Axelgaard J. Lateral electrical surface stimulation as an alternative to bracing in the treatment of idiopathic scoliosis. Treatment protocol and patient acceptance. Phys Ther. 1984;64:483–490		X		Intervention
Faizullin, I., & Faizullina, E. (2016). Effects of balance training on post-sprained ankle joint instability. International Journal of Risk & Safety in Medicine, 27(s1), S99–S101. https://doi.org/10.3233/jrs-150707		X		Population
Ferre CL, Brandao MB, Hung YC, Carmel JB, Gordon AM. Feasibility of caregiver-directed home-based hand arm bimanual intensive training: a brief report. Dev Neurorehabil. 2015;18:69-74		X		Outcome
Freeborn, D., & Knafl, K. (2014). Growing up with cerebral palsy: Perceptions of the influence of family. Child: Care, Health and Development, 40(5), 671–679. https://doi.org/10.1111/cch.12113		X		Population

Ghai, S., Ghai, I., & Effenberg, A. O. (2018). Effect of rhythmic auditory cueing on aging gait: A systematic review and meta-analysis. Aging and Disease, 9(5), 901–923. https://doi.org/10.14336/AD.2017.1031		X		Design
Goodwin J, Lecouturier J, Basu A, Colver A, Crombie S, Smith J, et al. Standing frames for children with cerebral palsy: a mixed-methods feasibility study. Health Technol Assess 2018;22(50)		X		Intervention
Goodwin, J., Lecouturier, J., Smith, J., Crombie, S., Basu, A., Parr, J. R., Howel, D., McColl, E., Roberts, A., Miller, K., & Cadwgan, J. (2019). Understanding frames: A qualitative exploration of standing frame use for young people with cerebral palsy in educational settings. Child: Care, Health and Development, 45(3), 433–439. https://doi.org/10.1111/cch.12659		X		Intervention
Gordon AM. To constrain or not to constrain, and other stories of intensive upper extremity training for children with unilateral cerebral palsy. Dev Med Child Neurol. 2011;53(suppl 4):56-6		X		Intervention
Gordon AM, Hung YC, Brandao M, et al. Bimanual training and constraint-induced movement therapy in children with hemiplegic cerebral palsy: a randomized trial. Neurorehabil Neural Repair. 2011;25:692-702.		X		Intervention
Guyard, A., Michelsen, S. I., Arnaud, C., & Fauconnier, J. (2017). Family adaptation to cerebral palsy in adolescents: A European multicenter study. Research in Developmental Disabilities, 61, 138–150. https://doi.org/10.1016/j.ridd.2016.11.010		X		Intervention
Harbourne, R. T., Willett, S., Kyvelidou, A., Deffeyes, J., & Stergiou, N. (2010). A Comparison of Interventions for Children With cerebral palsy to Improve Sitting Postural	X			

Control: A Clinical Trial. Physical Therapy, 90(12), 1881–1898. https://doi.org/10.2522/ptj.2010132				
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Heathcock JC, Lobo M, Galloway JC. Movement training advances the emergence of reaching in infants born at less than 33 weeks of gestational age: a randomized clinical trial. Phys Ther. 2008;88:310-322		X		Intervention
Hsin, Y. J., Chen, F. C., Lin, K. C., Kang, L. J., Chen, C. L., & Chen, C. Y. (2012). Efficacy of constraint-induced therapy on functional performance and health-related quality of life for children with cerebral palsy: A randomized controlled trial. Journal of Child Neurology, 27(8), 992–999. https://doi.org/10.1177/0883073811431011		X		Outcome
Jacobson, D. N. O., Löwing, K., Hjalmarson, E., & Tedroff, K. (2019). Exploring social participation in young adults with cerebral palsy. Journal of Rehabilitation Medicine, 51(3), 167–174. https://doi.org/10.2340/16501977-2517		X		Intervention
Jeng, S. C., Yeh, K. K., Liu, W. Y., Huang, W. P., Chuang, Y. F., Wong, A. M. K., & Lin, Y. H. (2013). A physical fitness follow-up in children with cerebral palsy receiving 12-week individualized exercise training. Research in Developmental Disabilities, 34(11), 4017–4024. https://doi.org/10.1016/j.ridd.2013.08.032	X			
Jiao, Y., Li, X. Y., & Liu, J. (2019). A New Approach to cerebral palsy Treatment: Discussion of the Effective Components of Umbilical Cord Blood and its Mechanisms of Action. Cell		X		Intervention

Transplantation, 28(5), 497–509. https://doi.org/10.1177/0963689718809658				
Katz-Leurer, M., Rotem, H., Keren, O., & Meyer, S. (2009). The effects of a “home-based” task-oriented exercise programme on motor and balance performance in children with spastic cerebral palsy and severe traumatic brain injury. Clinical Rehabilitation, 23(8), 714–724. https://doi.org/10.1177/0269215509335293			X	Population
Ko, E. J., Sung, I. Y., Yun, G. J., Kang, J. A., Kim, J. Y., & Kim, G. E. (2018). Effects of lateral electrical surface stimulation on scoliosis in children with severe cerebral palsy: a pilot study. Disability and Rehabilitation, 40(2), 192–198. https://doi.org/10.1080/09638288.2016.1250120	X			
Kuijper, M. A., Van Der Wilden, G. J., Ketelaar, M., & Gorter, J. W. (2010). Manual ability classification system for children with cerebral palsy in a school setting and its relationship to home self-care activities. American Journal of Occupational Therapy, 64(4), 614–620. https://doi.org/10.5014/ajot.2010.08087		X		Intervention
Langerak, N. G., Lamberts, R. P., Fieggen, A. G., Peter, J. C., Peacock, W. J., & Vaughan, C. L. (2009). Functional Status of Patients With cerebral palsy According to the International Classification of Functioning, Disability and Health Model: A 20-Year Follow-Up Study After Selective Dorsal Rhizotomy. Archives of Physical Medicine and Rehabilitation, 90(6), 994–1003. https://doi.org/10.1016/j.apmr.2008.11.019		X		Intervention
Langerak, N. G., Lamberts, R. P., Fieggen, A. G., Peter, J. C., Peacock, W. J., & Vaughan, C. L. (2009). Functional Status of Patients With cerebral palsy According to+B37		X		Population
Lopes, S., Magalhães, P., Pereira, A., Martins, J., Magalhães, C., Chaleta, E., & Rosário, P. (2018). Games used with serious purposes: A systematic review of interventions in patients		X		Design

with cerebral palsy . Frontiers in Psychology, 9(SEP). https://doi.org/10.3389/fpsyg.2018.01712				
Lorentzen, J., Greve, L. Z., Kliim-Due, M., Rasmussen, B., Bilde, P. E., & Nielsen, J. B. (2015). Twenty weeks of home-based interactive training of children with cerebral palsy improves functional abilities. BMC Neurology, 15(1), 1–12. https://doi.org/10.1186/s12883-015-0334-0	X			
Majnemer, A., Riley, P., Shevell, M., Birnbaum, R., Greenstone, H., & Coates, A. L. (2000). Severe bronchopulmonary dysplasia increases risk for later neurological and motor sequelae in preterm survivors. Developmental Medicine and Child Neurology, 42(1), 53–60. https://doi.org/10.1111/j.1469-8749.2000.tb00025.x		X		Intervention
McBurney, H., Taylor, N. F., Dodd, K. J., & Graham, H. K. (2003). A qualitative analysis of the benefits of strength training for young people with cerebral palsy. Developmental Medicine and Child Neurology, 45(10), 658–663. https://doi.org/10.1017/S0012162203001233	X			
Milton, Y., & Roe, S. (2017). Occupational therapy home programmes for children with unilateral cerebral palsy using bimanual and modified constraint induced movement therapies: A critical review. British Journal of Occupational Therapy, 80(6), 337–349. https://doi.org/10.1177/0308022616664738		X		Outcome
Monge Pereira, E., Molina Rueda, F., Alguacil Diego, I. M., Cano de la Cuerda, R., de Mauro, A., & Miangolarra Page, J. C. (2014). Empleo de sistemas de realidad virtual como método de propiocepción en parálisis cerebral: Guía de práctica clínica. Neurologia, 29(9), 550–559. https://doi.org/10.1016/j.nrl.2011.12.004		X		Language
Muriel, V., García-Molina, A., Aparicio-López, C., Enseñat, A., & Roig-Rovira, T. (2015). Relación entre el funcionamiento		X		Language

ejecutivo y la conducta en niños con parálisis cerebral. Revista de Neurologia, 61(8), 337–343. https://doi.org/10.33588/rn.6108.2015175				
Niiler, T. A., Nicholson, K., Fischer, L., & Lennon, N. (2019). Factors influencing post-surgical variability in StepWatch data in youth with cerebral palsy. Gait and Posture, 72, 234–238. https://doi.org/10.1016/j.gaitpost.2019.06.017		X		Intervention
Novak I, McIntyre S, Morgan C, et al. A systematic review of interventions for children with cerebral palsy: state of the evidence. Dev Med Child Neurol. 2013;55:885-910		X		Design
Palsdottir et al., 2020)Palsdottir, A., Gudmundsson, M., & Grahn, P. (2020). Equine-Assisted Intervention to Improve Perceived Value of Everyday Occupations and Quality of Life in People with Lifelong Neurological Disorders : A Prospective Controlled Study. International Journal of Environmental Research and Public Health, 17.		X		Population
Park EY, Kim WH. Meta-analysis of the effect of strengthening interventions in individuals with cerebral palsy. Res Dev Disabil. 2014;35:239-249		X		Design
Radtka, S., Hone, R., Brown, C., Mastick, J., Melnick, M. E., & Dowling, G. A. (2013). Feasibility of Computer-Based Videogame Therapy for Children with cerebral palsy. Games for Health Journal, 2(4), 222–228. https://doi.org/10.1089/g4h.2012.0071			X	Outcome
Ramstrand, N., & Lygnegård, F. (2012). Can balance in children with cerebral palsy improve through use of an activity promoting computer game? Technology and Health Care, 20(6), 501–510. https://doi.org/10.3233/THC-2012-0696	X			
Reubens, R., & Silkwood-Sherer, D. J. (2016). Intervention for an Adolescent with cerebral palsy during Period of			X	Intervention

Accelerated Growth. Pediatric Physical Therapy, 28(1), 117–125. https://doi.org/10.1097/PEP.0000000000000223				
Shea, T. M. O. (2008). Diagnosis, treatment, and prevention of cerebral p... [Clin Obstet Gynecol. 2008] - PubMed result. Clinical Obstetrics and Gynecology, 51(4), 816–828. http://phstwlp1.partners.org:2111/pubmed/18981805		X		Intervention
Stewart, D. A., Lawless, J. J., Shimmell, L. J., Palisano, R. J., Freeman, M., Rosenbaum, P. L., & Russell, D. J. (2012). Social participation of adolescents with cerebral palsy: Trade-offs and choices. Physical and Occupational Therapy in Pediatrics, 32(2), 167–179. https://doi.org/10.3109/01942638.2011.631100		X		Intervention
Surana, B. K., Ferre, C. L., Dew, A. P., Brandao, M., Gordon, A. M., & Moreau, N. G. (2019). Effectiveness of Lower-Extremity Functional Training (LIFT) in Young Children With Unilateral Spastic cerebral palsy: A Randomized Controlled Trial. Neurorehabilitation and Neural Repair, 33(10), 862–872. https://doi.org/10.1177/1545968319868719	X			
Sveistrup, H., Thornton, M., Bryanton, C., Mccomas, J., Marshall, S., Finestone, H., Mccormick, A., Mclean, J., Brien, M., Lajoie, Y., & Bisson, E. (2004). 10.1109@Iembs.2004.1404343. 2, 4856–4858.		X		Intervention
Terjesen T, Lange JE, Steen H. Treatment of scoliosis with spinal bracing in quadriplegic cerebral palsy. Dev Med Child Neurol. 2000;42:448–454.		X		Outcome
Wang, T. H., Liao, H. F., & Peng, Y. C. (2012). Reliability and validity of the five-repetition sit-to-stand test for children with cerebral palsy. Clinical Rehabilitation, 26(7), 664–671. https://doi.org/10.1177/0269215511426889		X		Intervention
Woolacott M, Shumway-Cook A, Hutchinson S, Ciol M, Price M, Kartin D. Effect of balance training on muscle activity used		X		Intervention

in recovery of stability in children with cerebral palsy: A pilot study. Dev Med Child Neurol 2005;47:455-461.				

Per reference the reason for exclusion. Incl., included; Ecl., excluded; T+A, Title and abstract; FT, Full text; RFE, Reason for exclusion.

PART 2 RESEARCH PROTOCOL

1 INTRODUCTION

Cerebral palsy (CP) is caused by an injury to the developing brain, resulting in a movement disorder (Wimalasundera & Stevenson, 2016). This disability has a prevalence of 2.11 per 1000 live births and is one of the most common causes of childhood physical disability (Oskoui et al., 2013). Children with CP encounter difficulties at all levels of the framework of international classification of functioning, disability and health (ICF): body structure, activity and participation (Wimalasundera & Stevenson, 2016). These children face various functional impairments, mainly spasticity, contractures, selective motor control and muscle weakness (Dietz & Sinkjaer, 2007; Wimalasundera & Stevenson, 2016). In addition, other impairments such as visual, communicative, behavioural and cognitive deficits interfere with the ability to function in daily life and may induce activity limitation (Bax et al., 2005). This results in reduced balance, specifically difficulties with anticipatory and reactive sitting and standing balance (Bigongiari et al., 2011; de Graaf-Peters et al., 2007; Schmit et al., 2016). Interventions during the childhood of these children are essential, since the combination of accelerated growth and spasticity is problematic for daily functional activities and mobility (Reubens & Silkwood-Sherer, 2016). Neuroplastic changes can be induced in people with lesions in the brain when therapeutic interventions are more intensive and longer than traditional physical therapy sessions of 30 minutes/session for three days/week during a couple of months. This increase in intensity of therapy can be achieved by home-based therapy (Lang et al., 2009; Tinderholt Myrhaug et al., 2015). The inclusion of virtual reality (VR) games creates an engaging and fun nature (Lopes et al., 2018), therefore VR can be a good alternative to increase the therapy intensity and to ensure therapy compliance of the child. Move It To Improve It (MiTii) is a cost-effective web-based therapy that can increase therapy intensity and is experienced to be engaging and fun (Bilde et al., 2011; Comans et al., 2017; James et al., 2015). Previous study showed no significant changes in balance after a home-based MiTii program (Bilde et al., 2011; Lorentzen et al., 2015), however VR has shown to be effective to improve balance in children with CP in a clinical setting (Wu et al., 2019). This difference in findings can be due to the difference in therapy duration and the amount of supervision. Previous study showed standing balance improvements in children with CP after a home-based tele-assisted robotic ankle training. This therapy provided passive stretching and active movement of the ankle with biofeedback using a portable rehabilitation robot to improve balance (K. Chen et al., 2014, 2016; Sukal-Moulton et al., 2014). However this portable rehabilitation robot is more expensive than de MiTii program. Therefore the aim of this multifactor repeated measurement design is to investigate possible benefits of a one-year home-based MiTii training program on balance in children with CP with GMFCS-level I-III in comparison with a one-year home-based tele-assisted robotic ankle training.

2 RESEARCH PURPOSE

The aim of this multifactor repeated measurement design is to investigate possible benefits of a one-year home-based MiTii training program on balance in children with CP with GMFCS-level I-III in comparison with a one-year home-based tele-assisted robotic ankle training.

2.1 Research questions

The key question of this research is: 'What is the influence of a one-year MiTii training program on balance in children between 7 and 18 years with CP with GMFCS-level I-III in comparison with a one-year home-based tele-assisted robotic ankle training?' This can be divided into three sub-questions:

1. What is the influence of a one-year MiTii training program on the static balance items of the PBS in children between 7 and 18 years with CP in comparison with a home-based tele-assisted robotic ankle training?
2. What is the influence of a one-year MiTii training program on the dynamic balance items of the PBS in children between 7 and 18 years with CP in comparison with a home-based tele-assisted robotic ankle training?
3. What is the influence of a one-year MiTii training program on the total score of the PBS in children between 7 and 18 years with CP in comparison with a home-based tele-assisted robotic ankle training?

2.2 Hypotheses

The following hypotheses were based on previous literature search:

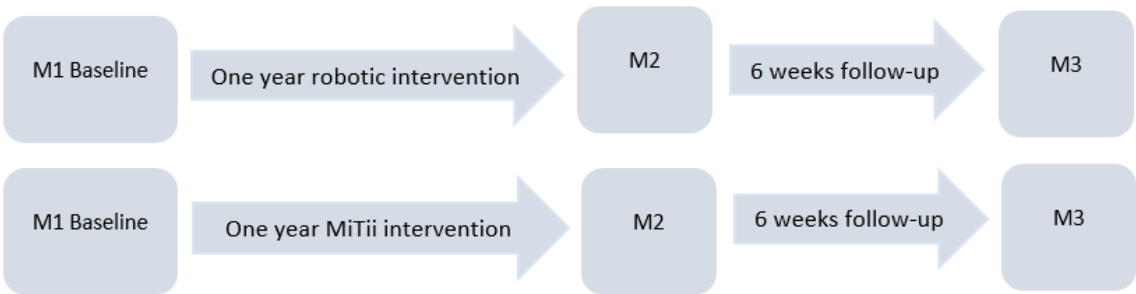
1. After a one-year MiTii training program, static balance in children between 7 and 18 years with CP improved significantly on the static balance items of the PBS.
2. After a one-year MiTii training program, dynamic balance in children between 7 and 18 years with CP improved significantly on the dynamic balance items of the PBS.
3. After a one-year MiTii training program, balance in children between 7 and 18 years with CP improved significantly on the PBS.

3 METHOD

3.1 Design

A multi factor repeated measurement design (Figure 1) will be used to investigate the influence of a one year home-based MiTii training on balance in children between 7 and 18 years with CP with GMFCS-level I-III compared with a one year home-based tele-assisted robotic ankle training. The participants will be screened on inclusion and exclusion criteria. The included participants will be assigned to the robotic group or MiTii group using a randomly generated number sequence. Before the intervention demographic data of the participants will be collected, namely age, sex, weight, height and subtype CP. The PBS, AROM and PROM will be evaluated at baseline, immediately after the one year intervention and at six weeks follow-up for the robotic and MiTii group. The participants will be evaluated by the same assessor, who will be blinded to the group assignment.

Figure 1 design



M = measuring moment

3.2 Participants

3.2.1 Inclusion criteria

The participants will be included by following criteria

- The participant is diagnosed with CP;
- The participant is aged between 7 and 18 years;
- The participant has GMFCS-level I-III;
- The participant is able to follow instructions during the session;
- The participant is able to express discomfort during the session;
- The participant has a caregiver that can set up the robotic ankle training.

3.2.2 Exclusion criteria

The participants will be excluded by following criteria

- The participant is not able to maintain a sitting position for one hour;
- The participant received surgery, serial casting or botulinum toxin injection in the past six month period before recruitment.

3.2.3 Recruitment

The children will be recruited from the Belgian Cerebral Palsy Register (BeCPR v.z.w.).

3.3 Medical ethics

Before the intervention will start the ethical approval will be obtained from the ethical commission of UHasselt. All participants and/or caregivers will receive the informed consent at the beginning of the intervention.

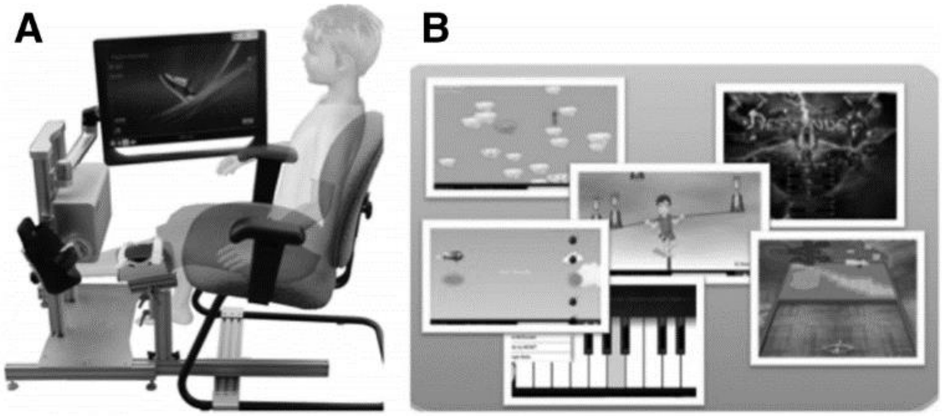
3.4 Intervention

Robotic group

The intervention protocol will be based on previous study by (K. Chen et al., 2014). The tele-assisted robotic ankle training (Figure 2) will be applied for one year in a home-setting. Before the start of the intervention the robot will be adjusted to the length of the foot and leg of the participant and be calibrated by the researchers. The researcher will teach the caregiver and the participant how to set up and use the portable rehabilitation robot until they both feel comfortable to use it. The caregivers will need to show their ability to use the robot before they can start with the intervention at home. If the caregiver have questions, they can contact the researcher through phone/email. The researcher will not visit the home of the participant to ensure the design of a home-based intervention.

The participants need to accomplish three sessions per week for one year. The affected limb will be attached in the portable rehabilitation robot. The participant will see a screen with active movement games that use biofeedback. Each session will include ten minutes of passive stretching, twenty minutes of active movement, followed by another ten minutes of passive stretching of the ankle. The active movements can be assisted or resisted by the robot. To provide tele-assistance there will be audio-visual interaction between the participant and the researcher through web-cameras and microphones to answer technical questions during the session. The researcher can follow the data (e.g. difficulty of the games) of these sessions because they will be uploaded to the server. After analysing this data, the researcher can adapt the session if needed. The robot will also record biomechanical measures. The passive range of motion (PROM) and active range of motion (AROM) will be monitored and saved. The participants will not receive any other therapy between these sessions.

Figure 2

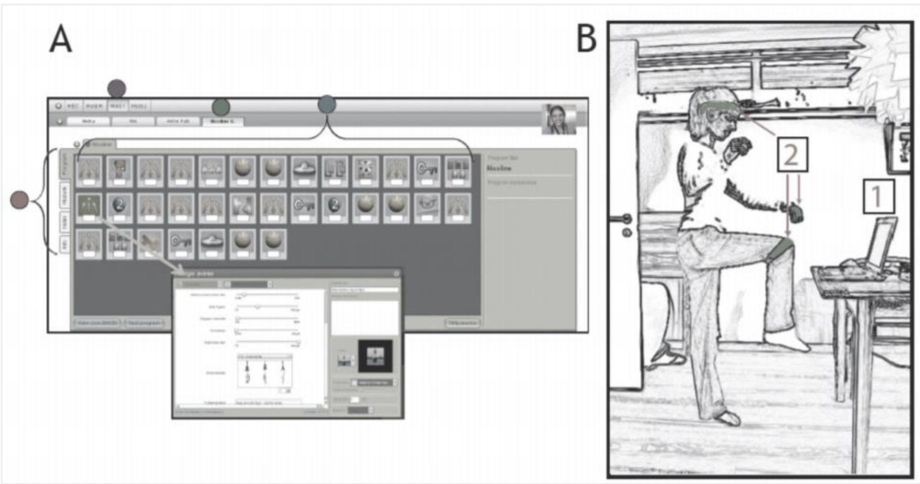


A Setup of the portable rehabilitation robot; B Screen of biofeedback games. (K. Chen et al., 2016)

MiTii group

The intervention protocol will be based on previous study by (Lorentzen et al., 2015). The MiTii training will be applied for one year in a home-setting. The participants need to accomplish a 30 minutes session three times a week. The MiTii set-up consisted of one computer with internet connection, a simple web-camera and five green bands (Figure 3).

Figure 3



A Screenshot of MiTii. The window show the training program of the individual patient. ; B Hardware. Computer with internet connection and a webcam (1) Green elastic bands placed around the head, wrists and knees (2) (Bilde et al., 2011)

The green bands will be placed on the head, wrist and knees of the participant. The MiTii games require the child to analyse visual information, solve a cognitive problem and respond with a motor act to objects presented on the screen. The web-camera will record the movements of the participant based on the green bands. The games can be divided in three categories according to their purpose. One category for the upper limb (e.g. popping a balloon with a needle) , one for the lower limb (e.g. flying UFO by shifting balance from side to side and moving up and down) and one for balance (e.g. flying a plane by shifting balance). The researcher can adjust the level of difficulty based on the progress of the child. This can be done throughout changing the difficulty of the perceptual, cognitive (e.g. more difficult questions) or motor challenges (e.g. higher repetitions). The researcher will not visit the home of the participant but will give the participant and the caregiver weekly feedback through Skype/email.

3.5 Outcome measures

The outcome measures will be collected at baseline, immediately after the intervention and at a six week follow-up.

3.5.1 Primary outcome measures

The primary outcome variable is a clinical measure, namely the PBS. This scale is a 14-item measure in which the children perform steady state and anticipatory balance activities. Each item will be scored on a 0 (unable to perform) to 4 (able to perform without difficulty) grading scale, with a maximal total score of 56 (Franjoine et al., 2003). The outcome scores of this test are PBS-static (6 items), PBS-dynamic (8 items) and PBS-total (C. Chen et al., 2013). Chen et al. confirmed good validity for the PBS. The PBS showed high test-retest reliability (ICC=0.998) and interrater reliability (ICC=0.997) (Franjoine et al., 2003). The minimal detectable change (MDC) for the PBS-static, PBS-dynamic and PBS-total were 0.79, 0.96 and 1.59, respectively. In addition the minimal clinically important difference (MCID) values are ranges of 1.47-2.92, 2.23-2.92 and 3.66-5.83 for PBS-static, PBS-dynamic and PBS-total, respectively (C. Chen et al., 2013).

3.5.2 Secondary outcome measures

Secondary outcome variables are biomechanical measures including AROM and PROM. The portable rehabilitation robot monitors and saves data of AROM and PROM for ankle dorsiflexion (K. Chen et al., 2014). The MiTii group and the robotic group will both be measured with the portable rehabilitation robot.

3.6 Data-analysis

To answer the research question, a data-analysis on analytics software JMP Pro will be conducted. To evaluate the effect of group (robotic, MiTii training) and time (baseline, immediately after, six weeks follow-up) on the PBS, AROM and PROM a mixed-model will be used. The response variable is the outcome of the PBS, AROM and PROM. The random covariate is the participant and the fixed covariates are group and time. The p-values are two-sided and will be considered significant below 0.05.

4 TIME PLANNING

This protocol will be executed from June 2020 until March 2022 (Table 1). The recruitment of the participants will start in June 2020 until August 2020. Before the start of the intervention the demographic data will be collected. AROM and PROM will be measured with the robot and balance will be evaluated with the PBS. The intervention will be applied for one year. Immediately after the intervention and at six weeks follow-up the PBS, AROM and PROM will be evaluated again. The data analysis will be performed from November 2021 until January 2022. Writing will be performed during the data analysis until March 2022.

Table 4 Time Planning

	June 2020	July 2020	August 2020	September 2020 – August 2021	September 2021	November 2021	December 2021	January 2022	February 2022	March 2022
Recruitment participants	x	x	x							
Collecting data 1				x						
Intervention				x	x					
Collecting data 2					x					
Collecting data 3						x				
Data analysis						x	x	x		
Writing								x	x	x

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UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2019-2020,
Registration form jury Master's thesis academic year 2019-2020,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1643629 Munsters Gwen**
Student number + name

Opleiding/*Programme*: **1 ma revalid. wet. & kine**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

Vul luik A aan. Bezorg het formulier aan je promotoren voor de aanvullingen in luik B. Zorg dat het formulier ondertekend en gedateerd wordt door jezelf en je promotoren in luik D en dien het in bij de juiste dienst volgens de afspraken in jouw opleiding.
Zonder dit inschrijvingsformulier krijg je geen toegang tot upload/verdediging van je masterproef.

Please read the information below carefully.

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Fill out part A. Send the form to your supervisors for the additions in part B. Make sure that the form is signed and dated by yourself and your supervisors in part D and submit it to the appropriate department in accordance with the agreements in your study programme.
Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:*

O behouden - *keep* BALANCE TRAINING FOR CHILDREN WITH CEREBRAL PALSY

● wijzigen - *change to:*
HOME - BASED BALANCE TRAINING FOR CHILDREN WITH CEREBRAL PALSY

/:

O behouden - *keep*

O wijzigen - *change to:*

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s):*

● behouden - *keep* PEETERS GITTE

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

O goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/*Thesis:*

O openbaar (beschikbaar in de document server van de universiteit)- *public (available in document server of university)*

O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

O de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

28-05-2020

Datum en handtekening promotor(en)
Date and signature supervisor(s)

Inschrijvingsformulier verdediging masterproef academiejaar 2019-2020,
Registration form jury Master's thesis academic year 2019-2020,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1643493 Peeters Gitte**
Student number + name

Opleiding/*Programme*: **1 ma revalid. wet. & kine**

INSTRUCTIES - *INSTRUCTIONS*

Neem onderstaande informatie grondig door.

Print dit document en vul het aan met DRUKLETTERS.

In tijden van van online onderwijs door COVID-19 verstuur je het document (scan of leesbare foto) ingevuld via mail naar je promotor. Je promotor bezorgt het aan de juiste dienst voor verdere afhandeling.

Vul luik A aan. Bezorg het formulier aan je promotoren voor de aanvullingen in luik B. Zorg dat het formulier ondertekend en gedateerd wordt door jezelf en je promotoren in luik D en dien het in bij de juiste dienst volgens de afspraken in jouw opleiding.
Zonder dit inschrijvingsformulier krijg je geen toegang tot upload/verdediging van je masterproef.

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Without this registration form, you will not have access to the upload/defense of your master's thesis.

LUIK A - VERPLICHT - IN TE VULLEN DOOR DE STUDENT
PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:*

O behouden - *keep* BALANCE TRAINING FOR CHILDREN WITH CEREBRAL PALSY

O wijzigen - *change to:*
HOME-BASED BALANCE TRAINING FOR CHILDREN WITH CEREBRAL PALSY

/:

O behouden - *keep*

O wijzigen - *change to:*

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s)*:

O behouden - *keep* MUNSTERS GWEN

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

O goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/*Thesis:*

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Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

O de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

28/05/2020

Datum en handtekening promotor(en)
Date and signature supervisor(s)

VOORTGANGSFORMULIER WETENSCHAPPELIJKE STAGE DEEL 1

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
13/11/2019	• Kennismaking promotor • Verdelen van onderwerpen	Promotor: Prof. Dr. P. Meyns Studenten: Gitte Peeters – Gwen munsters
7/01/2019	• Onderzoeksvraag + zoekstrategie	Promotor: Prof. Dr. P. Meyns Studenten: Gitte Peeters - Gwen Munsters
6/04/2019	• Methode + data-extractie • Lay-out / te gebruiken richtlijn	Promotor: Prof. Dr. P. Meyns Studente: Gitte Peeters - Gwen Munsters
29/05/2020	• Bespreken protocol	Promotor: Prof. Dr. P. Meyns Studenten: Gitte Peeters - Gwen Munsters
	<u>Niet-bindend advies:</u> De promotor verleent hierbij het advies om de masterproef WEL/NIET te verdedigen.	Promotor: Studente: Gitte Peeters – Gwen Munsters

Pieter MEYNS
aan mij, Gwen

12:39 (9 uur geleden)

Dag Gitte en Gwen,

Ik moet niets ondertekenen.
Jullie vullen zelf alles in en ik ben akkoord, want heb jullie gunstig advies gegeven.

Mvg,

--

Pieter Meyns
Assistant Professor - Biomechanics
REVAL - Rehabilitation Research

T +32(0)11 26 93 95

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Agoralaan Building A - B-3590 Diepenbeek
Office A0.02

Postal address:
Hasselt University
Martelarenlaan 42
B-3500 Hasselt

Pieter MEYNS
aan mij, Gwen

wo 20 mei 19:54 (7 dagen geleden)

Beste Gitte en Gwen,

Jullie krijgen een gunstig advies voor verdediging.

Mvg,

--

Pieter Meyns
Assistant Professor - Biomechanics
REVAL - Rehabilitation Research

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REVAL
REHABILITATION RESEARCH
UHASSELT

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen en Kinesitherapie, waarbij ik de kans krijg om in het kader van mijn opleiding, mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door Meyns Pieter en kadert binnen het opleidingsonderdeel Wetenschappelijke stage/masterproef deel 1. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Biomechanica (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

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- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
- het recht De Onderzoeksresultaten geheel of gedeeltelijk te (laten) bewerken of te (laten) vertalen en het (laten) reproduceren van die bewerkingen of vertalingen;
- het recht De Onderzoeksresultaten te (laten) bewerken of (laten) wijzigen, onder meer door het reproduceren van bepaalde elementen door alle technieken en/of door het wijzigen van bepaalde parameters (zoals de kleuren en de afmetingen).

De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleider Meyns Pieter.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

Naam: Munsters Gwen

Adres: Broedersgaarde 6, 3700 Tongeren

Geboortedatum en –plaats : 22/04/1998, Tongeren

Datum: 18/11/2019

Handtekening:

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen & Kinesitherapie waarbij ik de kans krijg om mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door Pieter Meyns en kadert binnen het opleidingsonderdeel Wetenschappelijke stage deel 1 Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Biomechanica (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

6. In zoverre De Onderzoeksresultaten auteursrechtelijk beschermd zijn, omvat bovenstaande overdracht onder meer de volgende exploitatiewijzen, en dit steeds voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding:

   - het recht om De Onderzoeksresultaten vast te (laten) leggen door alle technieken en op alle dragers;
   - het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;

[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
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De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleider Pieter Meyns

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

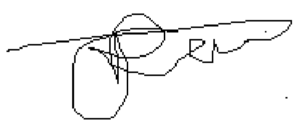
Naam: Gitte Peeters

Adres: Oude Watertorenstraat 24 3930 Hamont België

Geboortedatum en –plaats : 15/09/1998 , Lommel

Datum:14/11/2019

Handtekening:



BEOORDELING VAN DE WETENSCHAPPELIJKE STAGE-DEEL 1

Wetenschappelijke stage deel 1 (Masterproef deel 1- MP1) van de Master of Science in de revalidatiewetenschappen en de kinesitherapie bestaat uit **twee delen**:

1) De literatuurstudie volgens een welomschreven methodiek.
2) Het opstellen van het onderzoeksprotocol ter voorbereiding van masterproef deel 2.

Omschrijving van de **evaluatie**:

1) 80% van het eindcijfer wordt door de promotor in samenspraak met de copromotor gegeven op grond het product en van het proces dat de student doorliep om de MP1 te realiseren, met name het zelfstandig uitvoeren van de literatuurstudie en het zelfstandig opstellen van het onderzoeksprotocol, alsook de kwaliteit van academisch schrijven.
2) 20% van het eindcijfer wordt door de interne jury gegeven op grond van het ingeleverde product en de mondelinge presentatie waarin de student zijn/haar proces toelicht.

In de beoordeling dient onderscheid gemaakt te worden tussen studenten die, in samenspraak met de promotor, een nieuw onderzoek uitwerkten en studenten die instapten in een lopend onderzoek of zich baseren op voorgaande masterproeven of onderzoeksprojecten. Van deze laatste worden bijkomende inspanningen verwacht zoals bv. het bijsturen van de eerder geformuleerde onderzoeksvraag, de kritische reflectie over het onderzoeksdesign, het uitvoeren van een pilotexperiment.

Beoordelingskader:

Beoordelingskader: criteria op 20	
18-20	Excellente modelmasterproef
16-17	Zeer goede masterproef
14-15	Goede masterproef
12-13	Voldoende masterproef
10-11	Zwakke masterproef
≤ 9	Onvoldoende masterproef die niet aan de minimumnormen voldoet

ZELFEVALUATIERAPPORT

Onderstaand zelfevaluatierapport is een hulpmiddel om je wetenschappelijke stage -deel 1 zelfstandig te organiseren. Bepaal zelf je deadlines, evalueer en reflecteer over je werkwijze en over de diepgang van je werk. Check de deadlines regelmatig. Toets ze eventueel af bij je (co)promotor. Succes!

ZELFEVALUATIERAPPORT **WETENSCHAPPELIJKE STAGE - DEEL 1** **RWK**

LITERATUURSTUDIE	**Gestelde deadline**	**Behaald op**	**Reflectie**
De belangrijkste concepten en conceptuele kaders van het onderzoekdomein uitdiepen en verwerken	15/11/2020	15/11/2020	Onderzoeksdomein werd goed uitgediept en voorgesteld aan de hand van een mindmap die tijdens de masterproef verder werd aangevuld indien er extra informatie werd gevonden.
De belangrijkste informatie opzoeken als inleiding op de onderzoeksvraag van de literatuurstudie	2/04/2020	2/04/2020	Deze werd gevonden tijdens de voorbereidende literatuurstudie en aangevuld met relevante bronnen voor de uitspraken te staven van de inleiding.
De opzoekbare onderzoeksvraag identificeren en helder formuleren in functie van de literatuurstudie	28/11/2020	28/11	De onderzoeksvraag werd opgesteld door ons als studenten en bijgeschaafd door de promotor.
De zoekstrategie op systematische wijze uitvoeren in relevante databanken	20/12/2020	7/01	Wegens diepere inzichten in literatuur andere onderzoeksvraag geformuleerd, pas na de kerstvakantie mogelijkheid gehad om met promotor af te spreken.
De kwaliteitsbeoordeling van de artikels diepgaand uitvoeren	13/03/2020	13/03	Kwaliteitsbeoordeling werd uitgevoerd gedurende een periode dat beide studenten stage liepen, hierdoor heeft dit langer geduurd. Deze werd gedaan door beide studenten en nadien samen besproken. Indien er discussiepunten waren werd dit samen uitgespit. Alsook de biassen werden bepaald voor elk onderzoek.
De data-extractie grondig uitvoeren	19/03/2020	31/03/2020	Wegens ziekte van student is deze deadline uitgesteld. Tijdens de data-extractie werden er afspraken gemaakt om de gegevens op een conforme manier te noteren, zodanig dat er geen opvallende verschillen waren van notatie.
De bevindingen ïntegreren tot een synthese	04/04/2020	14/04/2020	Synthese/discussie werd gemaakt op basis van verschillende brainstorm momenten. Hierover werd dus voldoende en kritisch nagedacht.

ONDERZOEKSPROTOCOL	Gestelde deadline	Behaald op	Reflectie
De onderzoeksvraag in functie van het onderzoeksprotocol identificeren	15/04/2020	20/04/2020	Na feedback promotor over onderzoeksvraag, andere onderzoeksvraag opgesteld door studenten.
Het onderzoeksdesign bepalen en/of kritisch reflecteren over bestaande onderzoeksdesign	20/04/2020	20/04/2020	Onderzoeksdesign werd gebaseerd op een bestaande RCT en aangevuld met kritische bedenkingen van de studenten.
De methodesectie (participanten, interventie, uitkomstmaten, data-analyse) uitwerken	12/05/2020	15/05/2020	Voor het uitschrijven van de data analyse werd er gewacht op een te geven HC van het vak 'meetmethoden', hierdoor is dit later afgewerkt.

ACADEMISCHE SCHRIJVEN	Gestelde deadline	Behaald op	Reflectie
Het abstract tot he point schrijven	6/05/2020	6/05/2020	Het abstract werd gelijktijdig met de situering van onze masterproef geschreven.
De inleiding van de literatuurstudie logisch opbouwen	9/04/2020	9/04/2020	Er werden extra bronnen gezocht om de stellingen te staven. Ons onderzoeksdomein werd ook gekoppeld aan de huidige situatie door COVID-19.
De methodesectie van de literatuurstudie transparant weergegeven	20/03/2020	20/03/2020	De methode sectie werd gebaseerd op PRISMA op aanraden van de promotor.
De resultatensectie afstemmen op de onderzoeksvragen	19/03/2020	31/03/2020	We herkende een groei in het bondig beschrijven van de geïncludeerde studies.
In de discussiesectie de bekomen resultaten in een wetenschappelijke tekst integreren en synthetiseren	04/04/2020	14/04/2020	Er werden enkele discussiepuntjes toegevoegd na kritische opmerkingen van de promotor.
Het onderzoeksprotocol deskundig technisch uitschrijven	12/05/2020	15/05/2020	Voor het uitschrijven van de data analyse werd er gewacht op een te geven HC van het vak 'meetmethoden', hierdoor is dit later afgewerkt.
Referenties correct en volledig weergeven	15/05/2020	15/05/2020	Er werd gebruik gemaakt van Mendeley.

ZELFSTUREND EN WETENSCHAPPELIJK DENLEN EN HANDELEN: Peeters Gitte	Aanvangsfase	Tussentijdse fase	Eindfase
Een realistische planning opmaken, deadlines stellen en opvolgen	V	G	ZG
Initiatief en verantwoordelijkheid opnemen ten aanzien van de realisatie van de wetenschappelijke stage	ZG	G	ZG
Kritisch wetenschappelijk denken	V	G	G
De contacten met de promotor voorbereiden en efficiënt benutten	ZG	ZG	ZG
De richtlijnen van de wetenschappelijke stage autonoom opvolgen en toepassen	ZG	ZG	ZG
De communicatie met de medestudent helder en transparant voeren	ZG	G	ZG

De communicatie met de promotor/copromotor helder en transparant voeren	V	V	V
Andere verdiensten:			

ZELFSTUREND EN WETENSCHAPPELIJK DENLEN EN HANDELEN: Munsters Gwen	**Aanvangsfase**	**Tussentijdse fase**	**Eindfase**
Een realistische planning opmaken, deadlines stellen en opvolgen	V	V	G
Initiatief en verantwoordelijkheid opnemen ten aanzien van de realisatie van de wetenschappelijke stage	ZG	G	ZG
Kritisch wetenschappelijk denken	V	G	G
De contacten met de promotor voorbereiden en efficiënt benutten	G	ZG	ZG
De richtlijnen van de wetenschappelijke stage autonoom opvolgen en toepassen	ZG	ZG	ZG
De communicatie met de medestudent helder en transparant voeren	G	G	ZG
De communicatie met de promotor/copromotor helder en transparant voeren	V	V	V
Andere verdiensten:			