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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Balance during the 6MWT by people with MS

Jirka Dewaet
Fien Speelmans

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

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Prof. dr. Pieter MEYNS

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Acknowledgement

This research has been performed in the context of our master's thesis in rehabilitation science, which makes it possible to graduate as a physiotherapist at the University of Hasselt. This master's thesis was written during the entire academic year 21-22.

First of all we would like to take this opportunity to express our deepest appreciation and thanks to our promotor Prof. dr. Pieter MEYNS and co-promotor dra. Kyra THEUNISSEN, who made this work possible. Without their expertise and guidance, the realization of this master's thesis would not be possible.

Furthermore, a special thanks to all the participants and researchers, who took time to collaborate in this study. Without their effort and commitment, the completion of this thesis would not be imaginable.

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Last but not least, an acknowledgement for this wonderful collaboration. It makes all the hard work so much easier. The last few months were a rollercoaster of emotions for both of us, but at these moments we could find consolation with our friends and family.

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Research context

This master's thesis is situated within the neurological rehabilitation, specifically in the subdomain of biomechanics. It is part of an ongoing research project of dra. Kyra THEUNISSEN entitled '*The relation between walking, fatigability, walking economy and walking characteristics and the impact on social role participation and daily life activity in persons with Multiple Sclerosis and Rheumatoid Arthritis*'. The research is being conducted by a research group of the University of Hasselt (REVAL - study centre for rehabilitation research) in collaboration with a research team from the University of Maastricht (Nutrim - School for Nutrition and Translational Research in Metabolism and CAPHRI Research Institute for Healthcare and Public Health). The promoter of this ongoing research is Prof. dr. P. Feys, the co-supervisors are Prof. dr. A. Timmermans, dr. K. Meijer and Prof. dr. A. Boonen. This research took place in the medical centre of the university in Maastricht. The CAREN (Computer Assisted Rehabilitation Environment) was used to perform the walking test. It is a combination of an instrumented treadmill on a balance platform on a 3D motion capture, which is linked to a virtual reality environment (Collins et al., 2015).

The CAREN was created for multiple purposes: rehabilitation, research and sports. The system gives clear and objective data, real time feedback and gaming elements. These gaming elements ensure that the patients are more motivated. The system is suitable for a variety of conditions and it is adaptable to each individual's needs (Collins et al., 2015).

The purpose of this master's thesis is to examine if changes of balance occur during the 6 minute walking test (6MWT) in patients with multiple sclerosis (MS). To investigate the possible changes in gait stability, the spatiotemporal gait parameters (step length, step width, double support time and margin of stability) were used. It was hypothesized that changes in gait, especially to the end of the test, would be present. For the step length, a distinction was made between the most and least affected leg. We assume that there would be a difference in step length between both sides.

It is important to understand the biomechanical changes during walking for people with MS. Based on that, therapists can provide rehabilitation in the best possible way, taking into account the factors that may have an impact on the balance.

The research question was developed in consultation with Prof. dr. Pieter MEYNS and dra. Kyra THEUNISSEN. There was no contribution from JD and FS in the determination of the study design and method, because this master's thesis is part of an ongoing research project. There was also no contribution from JD and FS in the recruitment and data acquisition, as this was already completed. The data processing and academic writing were completely and independently performed by JD and FS under the supervision of Prof dr. Pieter MEYNS and dra. Kyra THEUNISSEN.

1. Abstract

Background: Multiple sclerosis (MS) is a chronic inflammatory and neurodegenerative immune disease. A common problem stated in people with MS are changes is a loss of balance. Loss of balance is the key factor for falls and it leads to an increased fear of falling. In addition to balance problems, they also suffer from walking deficits that are presented early in the disease (EDSS 0-1.5).

Objectives: The aim of this study is to investigate if there are any differences in balance during the six minute walk test (6MWT) in patients with MS.

Participants: Fourteen persons with MS were included in the study. The inclusion criteria were: age between 18-65 years; diagnosed with MS by a neurologist; EDSS score between 1-5.5 and they need to be able to walk without walking aids and orthoses.

Measurements: The 6MWT was performed on a multi-sensory Computer Assisted Rehabilitation environment (the CAREN system). During every minute of the test, data was collected with reflective markers attached to the body. The gait parameters: step width, step length (most and least affected leg), double support time and Margin of stability (MoS) were calculated to assess balance during gait.

Result: The majority of the participants (71,6%) had an EDSS score between 2-2.5 and the left side was most affected by 61.5% of the participants. Step length altered significantly (p = 0.0100) over the course of the 6MWT (both the least and the most affected side). No other outcomes showed differences over the course of the 6MWT.

Conclusion: In this population, no significant difference were found between the gait parameters during the 6MWT. There are no balance problems in people with MS with an average EDSS-score 2-2.5.

Keywords: multiple sclerosis, MS, gait, 6MWT, six minute walk test, balance, CAREN system

2. Introduction

Multiple sclerosis (MS) is a chronic inflammatory and neurodegenerative immune disease with demyelination and axonal loss of the spinal cord and the white matter of the brain (Prosperini & Castelli,2018). MS can be divided into relapsing-remitting MS (RRMS) or progressive MS (primary-progressive (PP), secondary-progressive (SP))(Lublin, 2014). The impairments associated with MS include: changes in the functions of sensory, motor and coordination systems, but not less important the changes in balance (Cameron & Nilsagard, 2018). There is a strong sensory contribution in balance dysfunctions in people with MS. The balance dysfunctions affects the performance during standing still and responding to perturbations (Cameron & Nilsagard, 2018).

Losing balance is the biggest cause of falls in people with MS, especially when there is a deterioration of the disease (Inojosa et al., 2020). About half of the people with MS (56%) experience a fall incident over a period of three to six months. In addition, 11 - 17% of falls lead to an injury (O'Malley et al.,2021). The most common situations in which people with MS fall are: indoors (65%), during the day, when they are walking and moving around the house and in general daily life activities (ADL), such as taking a shower (Cameron & Nilsagard, 2018).

People with MS have an increased fear of falling (60%). This causes them to avoid activities in daily life (80%). It has a major impact on their social life, as well on their participation in society (Cameron & Nilsagard, 2018). In addition, it leads to decreased independency and health related quality of life (QoL) (O'Malley et al.,2021).

A common symptom in people with MS is loss of balance and coordination. In this population, 50% to 80% suffer with balance problems (Cameron & Nilsagard, 2018).The balance problems are present in the relapse phases and also during the remitting phases, but it gets worse when people go through repeated relapses. People with progressive MS, who have no relapsing-remitting phases, also experience balance problems (Cameron & Nilsagard, 2018).

A second common problem in people with MS are walking deficits. They are present early in the disease (EDSS 0-1.5) and get worse over time. On average, people with MS walk more slowly (measured on a short distance; 10-meter walking test) and they have a shorter step and stride length, increased double-support time and swing time, but they also have a reduced cadence (Cameron & Nilsagard, 2018). When they walk for a longer distance (by example: 2 and 6 minute walking test), they have a reduced walking endurance (Cameron & Nilsagard, 2018). The difference in gait biomechanics between people with MS and healthy controls becomes more visible when they attempt to walk faster than their comfortable speed (Cameron & Nilsagard, 2018).

During walking, the centre of mass (CoM) is, most of the time, outside the base of support. This makes it challenging to stabilize the gait. Gait stability is defined as gait that does not lead to falls (Bruijn et al., 2013). Nevertheless, people with MS have an high incidence of falls. They demonstrated lower stability (bilaterally) than healthy individuals during gait (Lin et al., 2020).

People with MS often experience fatigue (90%) as one of the primary symptoms (Crenshaw et al., 2006). In the afternoon they reported a higher fatigue than in the morning (Ibrahim et al., 2020). During the 6MWT, people with MS demonstrated walking-related motor fatigue (Leone et al., 2015). A smaller step length, a shorter stride length, a prolonged stance and double support phase and a shorter single support phase were visible in individuals with motor fatigue (Kalron, 2015). The prevalence of motor fatigue was higher in more severely affected individuals (EDSS-score: 4.5-6.5), compared with individuals with and EDSS-score of 0-2.5 (Leone et al., 2015).

The six minute walk test (6MWT) originally evaluates the functional capacity through measuring the maximum distance that a patient can walk within six minutes (“ATS Statement”, 2002). For this research, the 6MWT was used to evaluate balance during walking. For measuring the potential balance problems, the spatiotemporal characteristics: step length (m), double support time (sec), step width (m) and MoS were used. The 6MWT has a good to excellent test-retest reliability for the spatiotemporal features (ICC ranged from 0.846 (0.696-0.929) to 0.919 (0.8400-0.957)) (Hadouiri et al., 2021).

3. Methods

3.1. Study population

MS patients were recruited from REVAL research centre of Hasselt University and the Rehabilitation & MS Center in Overpelt & Zuyderland hospital Heerlen in the period of 24/04/2019 – 01/02/2021.

3.1.1. Selection criteria

Participants were included in the study if they complied to the following criteria: 1) diagnosed with MS by a neurologist; 2) EDSS score from 1 to 5.5; 3) able to walk without walking aids and orthoses; 4) age between 18-65 years.

The exclusion criteria for this study were: 1) recent (3 months) relapse; 2) recent (12 months) arthroplasty or fracture; 3) comorbidities affecting functioning (for example: diabetes mellitus, malignancies or COPD); 4) contra-indications for physical activity or exertion tests; 5) Botulinum treatment in lower extremity <6 months before measurement. If any of the participants met one of the previous criteria, they were immediately excluded from the study.

3.2. Procedure

The CAREN is a versatile, multi-sensory Computer Assisted Rehabilitation Environment. It includes a six degrees of freedom motion platform, a dual belt treadmill (2 meter wide), two integrated force plates and it has a 180° cylindrical screen. The participants had 26 reflective markers attached to their skin over the whole body, with adhesive tape (human body model lower limb V2/HBM2 developed by Motek). These markers were needed to analyze the movements. Ten real-time infrared cameras capture these movements (Vicon Inc; Oxford, United Kingdom)

The CAREN has a self-paced mode on the treadmill. This means that the participants could walk at their own preferred speed. The treadmill automatically adjusted to the speed of the participants. When they walked more towards the front, the treadmill went faster. When they moved more to the back, the treadmill slowed down. As such, the participant always walks in the middle of the treadmill at his/her own pace. To standardize the test, the participants needed to wear standardized gym shoes. To prevent falling, they needed to wear an upper body safety harness. This harness was attached to a suspension system that was above the treadmill.

The participants were given time to familiarize walking in the CAREN system. People with MS have an increased fatigability. For this reason, the familiarization time was divided into two periods of three minutes, in this way the fatigability could be limited.

During the 6MWT, the participants needed to walk as much distance as possible during six minutes. Based on the articles of Hadouiri et al (2021); Kalron & Achiron (2014) and Kaipust et al (2012), the following spatiotemporal characteristics were included in the study: step length (most and least affected leg), step width, double support time and MoS medio-lateral (ML) and MoS backward-forward (BF). These parameters were calculated by the CAREN system. For the calculation of the MoS, the distance between the extrapolated center of mass (XCoM) and the limits of the base of support were used. A negative ML MoS resulted in a deviation of the straight walking pattern and a negative BF MoS gave a disturbance of the forward progression (Hak et al., 2013).

3.3. Data analysis

The statistical analysis was performed using JMP PRO 14.

The demographic characteristics that were used are: age (Y), gender (M/F), length (cm), weight (kg), phenotype MS (PP,RR,SP), disease duration (Y), EDSS score and affected side (Left/Right,0/1). For the following gait parameters: step width, double support time and MoS, the average of the left and right side were used.

Before the start of the statistical analysis, the normality and homoscedasticity was checked by JMP. The level of statistical significance was set at 5%. To check the normality, the '*shapiro-wilk test'* was used. The homoscedasticity was checked by the '*brown-forsythe test'*.

For the evaluation of the statistical results of the demographic characteristics, the mean value, standard deviation and the inter quartile range (IQR 25-75%) were used. To analyse the gait parameters (step length, step width, double support time and MoS), a mixed model was used to compare if there were differences between the minutes of the 6MWT. The fixed effect was the parameter time (min.), the random effect were the participants and the y-variables were the gait parameters, who are described above. A p-value less than 0.05 was considered as statistically significant.

In addition, the association between the step length of the most affected and least affected leg was investigated. Therefore, an extra column was created to calculate the difference between the step length of the most affected leg minus the least affected leg. The population consisted of less than 30 individuals, so it was obligated to check the normality. When there was a normal distribution, the paired t-test and wilcoxon signed rank test were used. When there was no normal distribution, the non-parametric wilcoxon signed rank test was used. In this situation, it was necessary to use the two-tailed (prob > /t/) test.

4. Results

4.1. Characteristics

The characteristics of the participants are presented in *table 1.* In *appendix 1,* the full data of the participants can be found.

There were 14 participants recruited for this study, most of them were masculine. The mean age was 46.93 years. In this study, most of the participants were classified with an EDSS score of 2-2.5.

Table 1
Characteristics (n=14)

	Mean	Std Dev	%
Age (Y)	46.93 (41-52.25)	9.68	
Sex, male			35.7
Length (cm)	171.20 (161.7-179.5)	9.41	
Weight (kg)	78.33 (66.2-87.7)	21	
Phenotype MS,			
PP			15.4
RR			76.9
SP			7.7
Disease duration (Y)	10.0 (8.5-12.1)	4.24	
EDSS score(Y)			
2			30.8
2.5			30.8
3			7.7
4			7.7
4.5			7.7
5			7.7
5.5			7.7
Affected side, left			61.5

Note: *The results were expressed in the form of mean and SD or median (IQR 25- 75), PP; primary progressive, RR; relapsing-remitting, SP; secondary progressive, EDSS; expanded disability status scale (0: no disability; 5: more severe disability)*

4.2. Gait parameters

The results from the data analysis of the gait parameters are presented in *table 2.* In *appendix 2,* the full data of the participants can be found.

The assumption *'normality'* was only achieved for the step width ($p = 0.8173$). For the other gait parameters, there was no normal distribution found ($p < 0.05$). There was no equal variance present for step width ($p < 0.001$) and step length of the least affected leg ($p = 0.0009$). None of the gait parameters fulfilled both of the assumptions of normal distribution and equal variance. For this reason, the interpretation of the results were done with caution.

The gait parameters that has an influence on the gait stability, were not changed enough to indicate significant balance problems during the 6MWT. There was no significant effect of time on gait stability.

On the other hand, the step length of the most and least affected leg was not the same in people with MS. There was a statistical significant difference ($p = 0.0100$) between the mean value of the step length of the most and least affected leg.

Table 2
Results gait parameters

	Mean (± SD)	Shapiro-wilk test (p-value)	Brown forsythe test (p-value)	F-test (p-value)	Wilcoxon signed rank test (p-value)
Step length					
Step length most affected leg (m)	0.6331 (± 0.1695)	<0.001*	0.2577	0.6633	0.0100*
Step length least affected leg (m)	0.6347 (± 0.1733)	0.0358*	0.0009*	0.2838	
MoS					
MoS ML	0.0592 (± 0.0156)	<0.001*	0.1468	0.1331	
MoS BF	-0.2019 (± 0.1078)	<0.001*	0.5305	0.2600	
Double support (s)	0.1172 (± 0.0303)	0.0074*	0.0533	0.3814	
Step width (m)	0.2111 (± 0.0627)	0.8173	<0.001*	0.8345	

***Note**: *;statistical significant (p<0.05), Mos ML; margin of stability medio-lateral, MoS BF; margin of stability backward-forward; SD, standard deviation*

5. Discussion

The present study examined balance during the 6MWT. There were no significant differences found for the gait parameters (step length, step width, double support time and MoS). Based on this study, there were not immediately serious balance problems found in people with MS during the 6MWT. However, there was a significant difference between the step length of the most and least affected leg.

Escudero-Uribe et al (2019) investigated the effect of the 6MWT on spatiotemporal gait parameters in people with MS. The gait pattern gets more affected after performing the 6MWT, but this is only present in moderate-severe people with MS who had an EDSS ≥ 4.0.
The step width (cm) was significantly higher in the severe and moderate group, in comparison with the mild and control group. The difference in step length between the most and least affected leg was significantly higher in the severe group than in the mild and control group (Escudero-Uribe et al., 2019; Abasiyanik et al., 2022). The severe and moderate group showed more changes in double support time, compared to the mild group of people with MS.
In the mild group with a mean EDSS-score of 2.4 were no significant changes found for these gait parameters (Escudero-Uribe et al., 2019; Abasiyanik et al., 2022).
The 6MWT has a strong significant negative correlation with the EDSS-score (Goldman et al., 2008).
The population of this master's thesis (mean EDSS 2.0-2.5) was comparable with the mild group of the previous studies (mean EDSS 2.4). There were no significant difference in gait parameters found during the 6MWT, this can be due to the low EDSS-scores of the participants.

An extra gait parameter to measure balance during walking is the local dynamic stability (LDS). It is an approach to reflect the ability of the locomotor system to cope with perturbations that occur naturally during walking (Dingwell et al., 2001). LDS is measured by the local divergence/lyapunov exponent (Caronni et al.,2020).

The higher the LDE value, the less stable a person walks or the less well the body can adapt to disturbances (Caronni et al.,2020). People with MS walked significantly more unstable, compared to healthy controls (Caronni et al., 2020; Lizama et al., 2020; Abasiyanik et al., 2022) Arpen et al (2020), has investigated the LDS during the 6MWT. They concluded that people with MS had a decreased stability over time, compared with the control group. However, these differences only occurred from minute 4 of the 6MWT (Arpen et al., 2020).
The fact that Arpen et al (2020) did find a difference, may be due to the EDSS-score of their participants. The EDSS-score of the participants of Arpen et al (2020) was higher (mean: 3.5) than those in our study (mean: 2.5). It is possible that the walking related fatigue was not present yet by our participants.
Otherwise, it could be that the LDS is more sensitive to changes in balance during walking in comparison to the gait parameters that were used in this study.

Walking speed has an influence on the balance problems while walking in people with MS. This factor can be one of the reasons why there was no significant difference found in this study. The studies of Dingwell et al (2007) and Kang & Dingwell (2008) researched the effect of the walking speed. They not only looked at the preferred walking speed, but also included slower and/or faster walking. When the walking speed deviates from the preferred walking speed, the degree of instability becomes more visible (Dingwell et al., 2007; Kang & Dingwell, 2008). Even when people with a low EDSS-score need to walk at a higher pace, they are more challenged to keep their gait stability under control (Gorgas et al., 2015). For the gait parameter double support time, in the fast speed condition after performing the 6MWT, there was a significant increase compared with the comfortable speed (Abasiyanik et al., 2022).

The first limitation of this study is the absence of a healthy control group. In case of an altered gait pattern, a comparison with the gait pattern of healthy controls was not possible.
Secondly, this was an investigation with a small sample size (n=14), so applicability of these findings to others with MS is not known. The sample mainly consisted of people with mild disability. Care must be taken before the generalization of the results in patients with moderate to severe disability, because the level of disability has an influence on the gait patterns. In addition, the 6MWT was performed with self-selected pace. Further investigating of the 6MWT with different speed conditions must be done. Gait stability is more challenged when people with MS needs to walk faster.
Subsequently, the assumptions of the data analysis were not fulfilled. The data is not completely reliable, a caution interpretation of the result is recommended.

In the data set there was one value that was aberrant, compared to the other results. The step length of the most affected leg (0.87m) is twice the value of the step length of the least affected leg (0.43m) of participant 1. This outlier can influence the results. It can be related to a measurement error.

The strength of this study is the standardized protocol of the test. The participants underwent the test in the same environment and sequence. The CAREN system try to imitate walking in the natural environment. The system adjust automatically to the walking speed of the participant.

6. Conclusion

In conclusion, this study showed that people with mild disability (mean EDSS-score: 2.5) had no problems in gait stability, during the 6MWT at their self-selected walking pace.
An asymmetry in step length was found between the most and least affected leg, but this can maybe related to an outlier in the data set.

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Appendix

Appendix 1
Demografic characteristics

PTnr	Age (y)	Gender (m/f, 0,1)	Length(cm)	Weight(kg)	PhenotypeMS	Diagnose MS	Disease duration (y)	EDSS	AffSide (left/right,0/1)
1	50	1	162.01	72.2	RR	1/09/2010	8.647222222	5	0
2	52	0	179	68	PP	1/08/2015	3.866666667	4.5	0
3	49	1	169	61	RR	24/06/2003	16	2.5	0
5	44	1	/	125.1	PP	26/04/2018	1.280555556	5.5	0
9	46	1	157	67.9	/	20/12/2008	11	2.5	1
12	53	1	170	95.4	RR	1/06/2002	17.64444444	4	1
13	37	1	161.1	53.6	RR	1/06/2011	8.691666667	2	0
14	44	0	186.5	85.1	RR	11/07/2010	9.580555556	2.5	1
16	49	1	177	73.5	RR	1/08/2008	11.50833333	2.5	0
17	42	0	178	81.5	RR	11/04/2006	13.83888889	3	0
18	38	1	164.5	72.8	RR	1/03/2010	9.922222222	2	1
19	27	1	161.5	49.4	RR	26/02/2010	10	2	1
22	64	0	180	112.1	SP	15/02/2012	8.033333333	/	0
24	62	0	180	79	RR	26/10/2010	10	2	/

***Note**: RR; relapsing-remitting, PP; primary progressive, SP; secondary progressive*

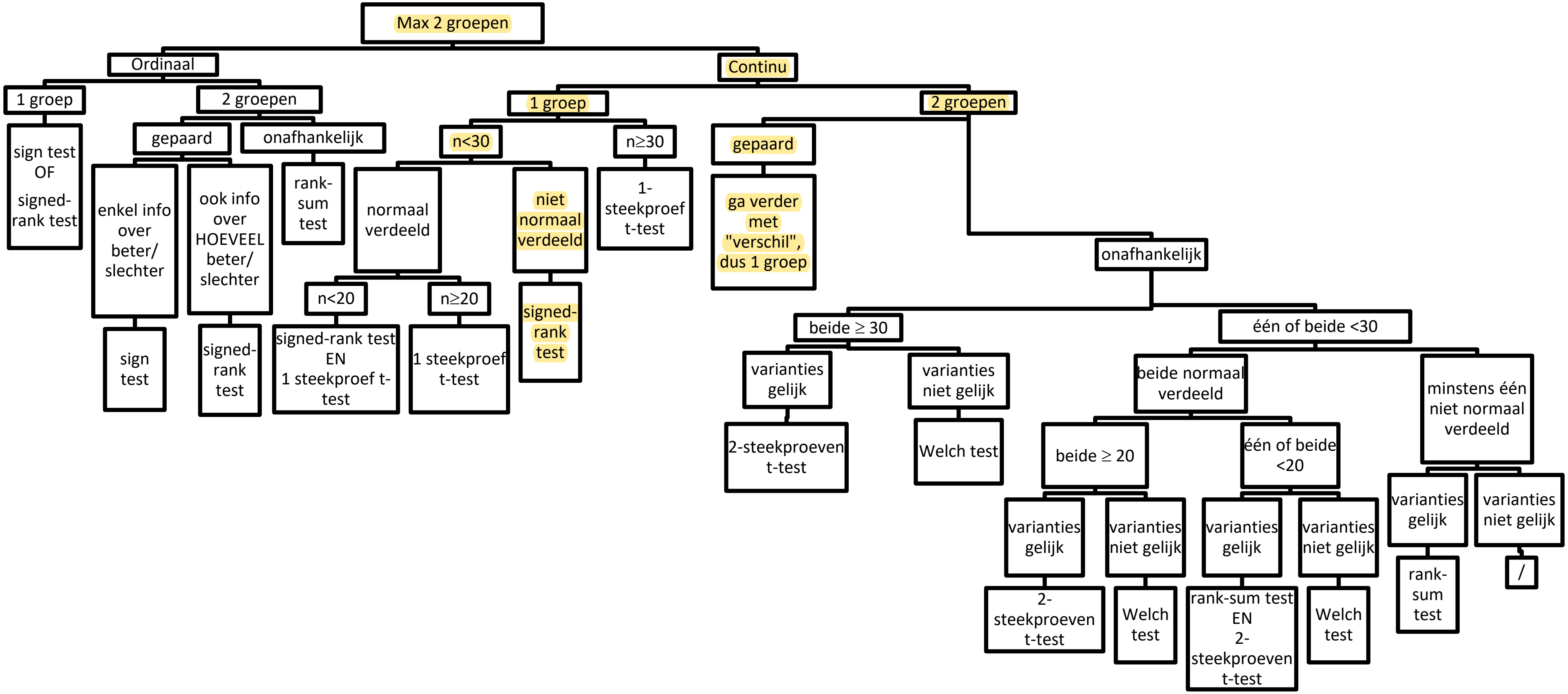
Appendix 2

Data gait investigation (CAREN system)

Participant	Time (min)	Step length most affected leg (m)	Step length least affected leg (m)	Step width (m)	Double support (s)	MoS ML	MoS BF
1	1	0.87	0.43	0.265	0.16	0.043	-0.086
1	2	0.47	0.45	0.28	0.15	0.046	-0.102
1	3	0.47	0.46	0.27	0.145	0.044	-0.107
1	4	0.46	0.46	0.265	0.155	0.044	-0.102
1	5	0.45	0.44	0.27	0.155	0.047	-0.11
1	6	0.44	0.4	0.285	0.16	0.045	-0.105
2	1	0.72	0.76	0.23	0.12	0.065	-0.199
2	2	0.77	0.82	0.225	0.095	0.065	-0.264
2	3	0.8	0.84	0.22	0.095	0.067	-0.283
2	4	0.81	0.85	0.215	0.095	0.064	-0.278
2	5	0.8	0.84	0.215	0.095	0.063	-0.273
2	6	0.82	0.86	0.205	0.095	0.061	-0.286
3	1	0.66	0.66	0.25	0.1	0.083	-0.216
3	2	0.67	0.67	0.24	0.1	0.083	-0.226
3	3	0.65	0.67	0.26	0.1	0.089	-0.228
3	4	0.66	0.65	0.245	0.105	0.085	-0.232
3	5	0.7	0.68	0.24	0.09	0.081	-0.283
3	6	0.7	0.66	0.23	0.09	0.076	-0.292
5	1	0.62	0.62	0.335	0.135	0.082	-0.141
5	2	0.6	0.6	0.34	0.14	0.083	-0.133
5	3	0.56	0.57	0.34	0.15	0.093	-0.117
5	4	0.44	0.48	0.33	0.17	0.088	-0.112
5	5	0.42	0.45	0.33	0.18	0.078	-0.094
5	6	0.46	0.47	0.345	0.165	0.075	-0.102
9	1	0.51	0.51	0.235	0.145	0.037	-0.076
9	2	0.52	0.52	0.23	0.14	0.038	-0.076

9	3	0.52	0.52	0.22	0.14	0.042	-0.078
9	4	0.52	0.52	0.21	0.145	0.045	-0.12
9	5	0.52	0.5	0.22	0.15	0.037	-0.074
9	6	0.49	0.48	0.21	0.155	0.031	-0.057
12	1	0.39	0.4	0.215	0.115	0.049	-0.28
12	2	0.39	0.41	0.215	0.12	0.075	-0.159
12	3	0.35	0.38	0.22	0.12	0.075	-0.15
12	4	0.31	0.33	0.22	0.13	0.064	-0.195
12	5	0.26	0.29	0.215	0.13	0.073	-0.129
12	6	0.21	0.25	0.225	0.145	0.079	-0.109
13	1	0.75	0.74	0.11	0.075	0.048	-0.293
13	2	0.77	0.77	0.11	0.065	0.05	-0.32
13	3	0.77	0.77	0.11	0.065	0.051	-0.33
13	4	0.78	0.79	0.115	0.065	0.053	-0.35
13	5	0.79	0.79	0.115	0.06	0.054	-0.359
13	6	0.77	0.8	0.125	0.065	0.056	-0.358
14	1	0.65	0.64	0.175	0.135	0.031	-0.187
14	2	0.7	0.69	0.17	0.12	0.032	-0.218
14	3	0.75	0.73	0.175	0.11	0.033	-0.255
14	4	0.75	0.76	0.2	0.16	0.033	-0.208
14	5	0.76	0.77	0.19	0.11	0.032	-0.271
14	6	0.76	0.78	0.185	0.105	0.032	-0.27
16	1	0.8	0.84	0.135	0.085	0.059	-0.317
16	2	0.82	0.84	0.135	0.085	0.058	-0.322
16	3	0.83	0.84	0.15	0.085	0.063	-0.334
16	4	0.85	0.86	0.155	0.085	0.067	-0.351
16	5	0.88	0.88	0.165	0.075	0.069	-0.407
16	6	0.9	0.88	0.155	0.06	0.065	-0.463
17	1	0.74	0.73	0.19	0.09	0.063	-0.259
17	2	0.75	0.76	0.19	0.095	0.063	-0.268
17	3	0.76	0.79	0.19	0.095	0.064	-0.282

17	4	0.79	0.81	0.185	0.095	0.065	-0.3
17	5	0.79	0.82	0.185	0.09	0.066	-0.31
17	6	0.81	0.83	0.185	0.09	0.066	-0.328
18	1	0.49	0.53	0.13	0.13	0.057	-0.115
18	2	0.6	0.62	0.13	0.115	0.059	-0.148
18	3	0.6	0.62	0.125	0.11	0.058	-0.152
18	4	0.59	0.62	0.12	0.11	0.059	-0.157
18	5	0.6	0.62	0.11	0.1	0.057	-0.16
18	6	0.58	0.61	0.1	0.105	0.054	-0.155
22	1	0.78	0.79	0.19	0.12	0.052	-0.234
22	2	0.79	0.78	0.185	0.115	0.037	-0.234
22	3	0.73	0.74	0.205	0.13	0.056	-0.204
22	4	0.79	0.8	0.205	0.115	0.054	0.255
22	5	0.78	0.78	0.19	0.12	0.052	-0.237
22	6	0.79	0.8	0.2	0.105	0.055	-0.259
24	1	0.37	0.35	0.28	0.155	0.063	-0.126
24	2	0.4	0.38	0.29	0.155	0.067	-0.122
24	3	0.42	0.4	0.28	0.155	0.063	-0.118
24	4	0.4	0.39	0.29	0.155	0.066	-0.113
24	5	0.44	0.4	0.28	0.16	0.066	-0.11
24	6	0.5	0.47	0.29	0.14	0.072	-0.122



Max 2 groepen
Ordinaal
1 groep
sign test OF signed-rank test
2 groepen
gepaard
enkel info over beter/ slechter
sign test
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signed-rank test
onafhankelijk
rank-sum test
Continu
1 groep
n<30
normaal verdeeld
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signed-rank test EN 1 steekproef t-test
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2-steekproeven t-test
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beide ≥ 20
varianties gelijk
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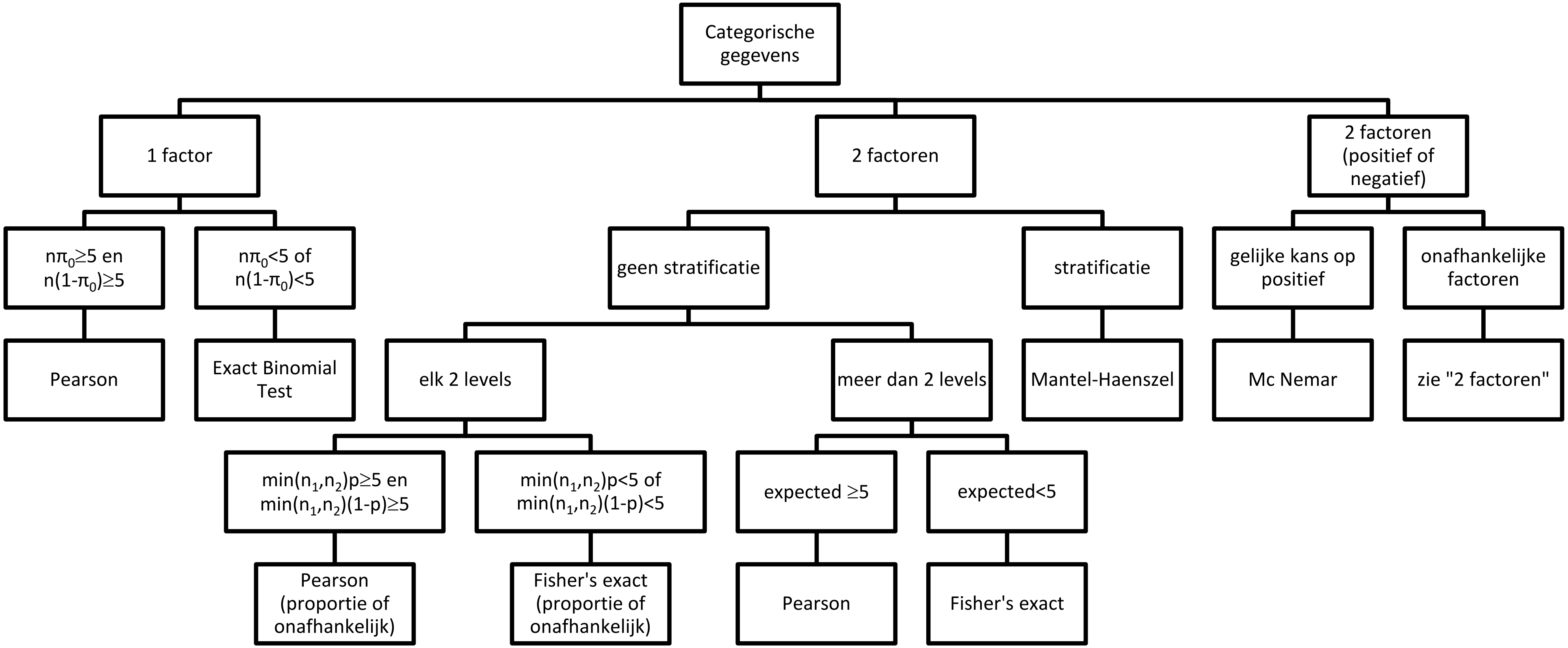
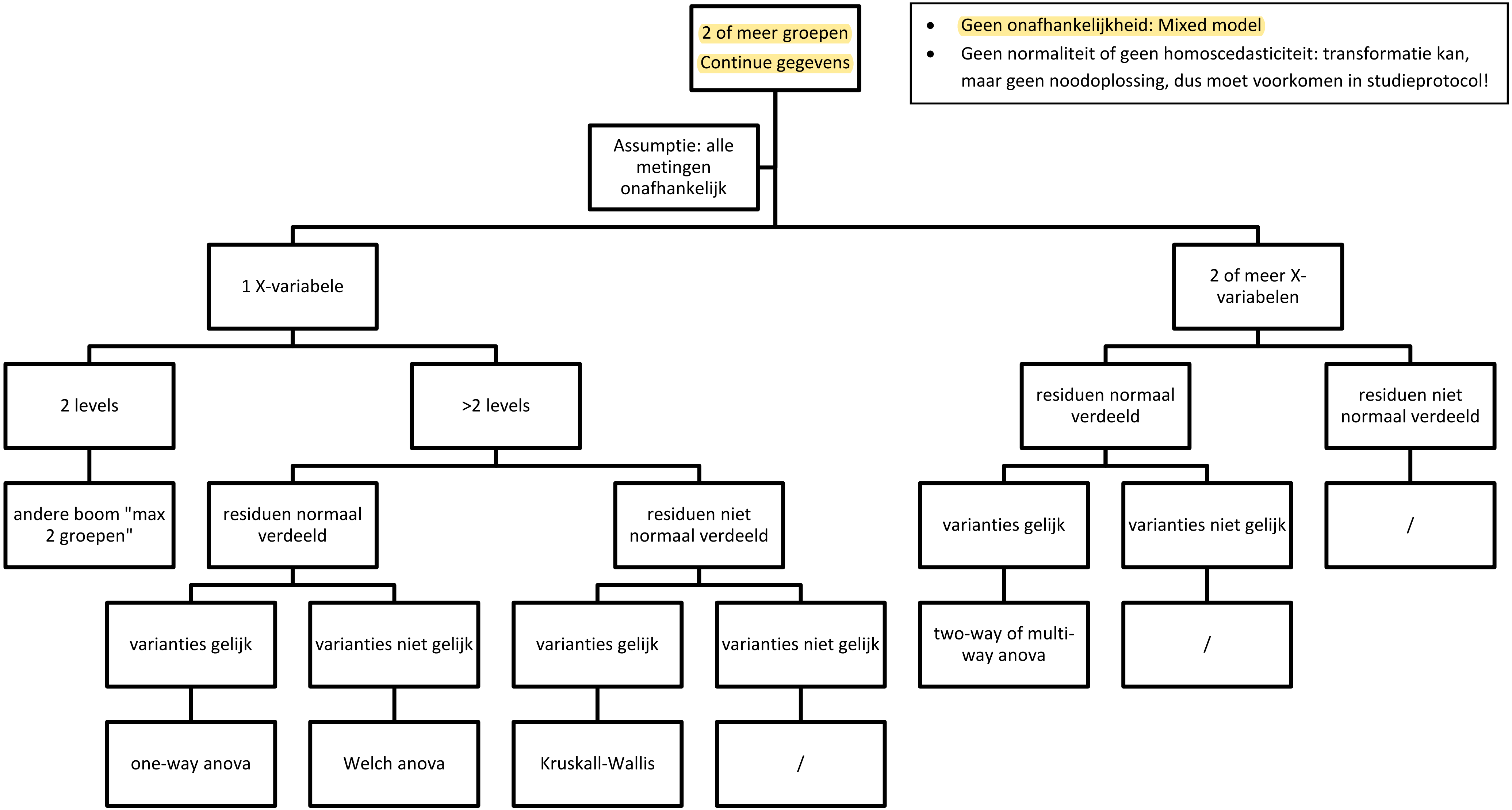
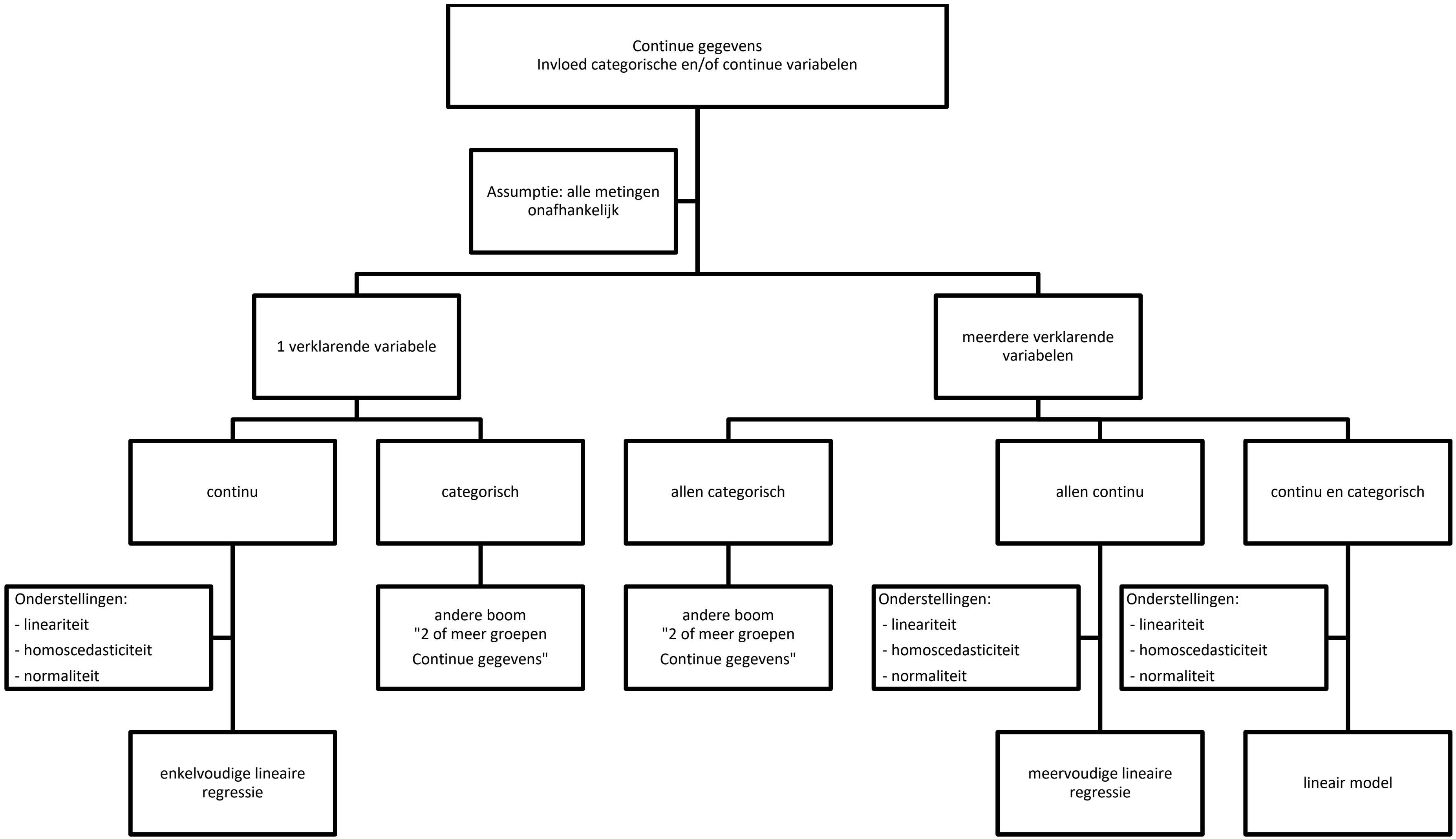

Categorische gegevens
1 factor
2 factoren
2 factoren (positief of negatief)
$n\pi_0 \geq 5$ en $n(1-\pi_0) \geq 5$
$n\pi_0 < 5$ of $n(1-\pi_0) < 5$
geen stratificatie
stratificatie
gelijke kans op positief
onafhankelijke factoren
Pearson
Exact Binomial Test
elk 2 levels
meer dan 2 levels
Mantel-Haenszel
Mc Nemar
zie "2 factoren"
$\min(n_1,n_2)p \geq 5$ en $\min(n_1,n_2)(1-p) \geq 5$
$\min(n_1,n_2)p < 5$ of $\min(n_1,n_2)(1-p) < 5$
expected ≥5
expected<5
Pearson (proportie of onafhankelijk)
Fisher's exact (proportie of onafhankelijk)
Pearson
Fisher's exact

- Geen onafhankelijkheid: Mixed model
- Geen normaliteit of geen homoscedasticiteit: transformatie kan, maar geen noodoplossing, dus moet voorkomen in studieprotocol!




Continue gegevens
Invloed categorische en/of continue variabelen
Assumptie: alle metingen onafhankelijk
1 verklarende variabele
meerdere verklarende variabelen
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categorisch
allen categorisch
allen continu
continu en categorisch
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
andere boom "2 of meer groepen Continue gegevens"
andere boom "2 of meer groepen Continue gegevens"
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
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INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
23/11/21	online meeting: Schetsing thema van masterproef deel 2	Promotor: Copromotor/Begeleider: Student(e): Student(e):
01/12/22	online meeting: goedkeuring onderzoeksvraag, bespreking statestiek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
09/02/2022	e-mail: verkrijgen databestanden lopend onderzoek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
02/03/22	online meeting: bespreking databestanden proefpersonen.	Promotor: Copromotor/Begeleider: Student(e): Student(e):
10/03/22	e-mail: Informatie verkregen in verband met de methode van de lopende studie.	Promotor: Copromotor/Begeleider: Student(e): Student(e):
25/03/22	e-mail: eerste feedback over onze introductie, research context en methode	Promotor: Copromotor/Begeleider: Student(e): Student(e):
26/04/22	online meeting: vragen in verband met de interpretatie van onze statistische verwerking	Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Fien Speelmans en Jirka Dewaet

Datum:06/06/2022

Titel Masterproef: Balance during the six minute walking test by people with MS

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde: - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering. - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering. - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	O	O	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Data management	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	O	O	O	O	O

2) Niet-bindend advies: Student(e) krijgt toelating/geen toelating (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

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

Stamnummer + naam: **1747167 Speelmans Fien**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

INSTRUCTIES - *INSTRUCTIONS*

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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.
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PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

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O behouden - *keep*

O wijzigen - *change to:*

/:

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):* DEWAET JIRKA

O behouden - *keep*

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)

28/05/2022

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

UHASSELT
KNOWLEDGE IN ACTION

Inschrijvingsformulier verdediging masterproef academiejaar 2021-2022,
Registration form jury Master's thesis academic year 2021-2022,

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Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1745752 Dewaet Jirka**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

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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:* BALANCE DURING THE 6MWT BY PEOPLE WITH MS

O behouden - *keep*

O wijzigen - *change to:*

/:

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)*: SPEELMANS FIEN

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O wijzigen - *change to:*

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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)

27/5/'22

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

UHASSELT

Fien Speelmans <fien.speelmans@student.uhasselt.be>

niet bindend advies masterproef deel 2

Pieter MEYNS <pieter.meyns@uhasselt.be> 30 mei 2022 om 11:37
Aan: Fien Speelmans <fien.speelmans@student.uhasselt.be>
Cc: Kyra THEUNISSEN <kyra.theunissen@uhasselt.be>, Jirka Dewaet <jirka.dewaet@student.uhasselt.be>

Beste Fien en Jirka,

Via deze mail geef ik jullie een gunstig advies om jullie thesis in the dienen voor openbare verdediging.
Dit geeft geen zekerheid mbt eindscore of slagen of niet slagen.

Jullie moeten deze e-mail van mij afdrukken en mee indienen bij het uploaden van jullie inschrijvings- en inventarisatieformulier (die laatste miste nog wel).

Ik tracht nog tijd te maken voor specifieke feedback, maar kan niet beloven tegen wanneer dit lukt.

Met vriendelijke groeten,

--

Pieter Meyns
Assistant Professor - Biomechanics
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REHABILITATION RESEARCH
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Op zo 29 mei 2022 om 12:25 schreef Fien Speelmans <fien.speelmans@student.uhasselt.be>:
[Tekst uit oorspronkelijke bericht is verborgen]