TEST-RETEST RELIABILITY OF THE GAITRite® system ON HEALTHY ADULTS

A Bachelor thesis

By

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Preface

This graduation assignment before you, reflects my interest and hard work. It is a practical research which was conducted at the Hanze University of applied Sciences Groningen to access the reliability of the GAITRite® system. The complexity of human movement has always intrigued me. In my physiotherapy study, I have come across various methods and devices that have been employed to quantify and analyse gait patterns. The GAITRite® system is one of the most modern instruments in quantifying the parameters of gait and out of curiosity I wanted to know if the system is reliable.

I would like to use this opportunity to appreciate those who helped make this graduation assignment a success. I first want to thank Hans van de Leur my client and coordinator of the research project for his assistance and guidance through-out the whole process. Without his help this research could not have been possible. I also want to thank my supervisor Anne Griet Brader whose help and feedback were instrumental in this research. Finally, I would like to thank the participants without whom this study would not have taken place.

I hope you will have pleasure reading this thesis.

Ogbonna Ebeke

26-04-2017, Groningen.

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Abstract

Introduction: *Quantifying the parameters of gait is usually a complex task for researchers and therapists. There have been various techniques employed over the years to assess the parameters of gait such as visual observation, paper walk way and many more. In recent years, the GAITRite® system has become popular and is frequently used to quantify the parameters of gait as well as setting baseline for clinicians. Studies have shown that the GAITRite® system is a valid instrument for assessing gait parameters; however, there has been limited research performed studying the reliability of the system using large number of participants. The purpose of this study is therefore to assess the test-retest reliability of the GAITRite® system on healthy adults.*

Method: *A total number of 179 subjects participated in this study of which 74 were male while 105 were female. The participants of this study were first year physiotherapy students of the Hanze University of Applied Sciences Groningen. The participants were tested in the Hanze active ageing lab (HAAL) using the GAITRite® system. Twelve temporal and spatial gait parameters were assessed; these included velocity, cadence, step time, step length, cycle time, stride length, swing time, stance time, toe in/toe out, heel to heel base of support, single support time and double support time.*

Result*: The mean age of the 179 subjects was 20 (range 18-28, SD: 2.0). From the evaluated gait parameters heel to heel base of support showed a strong correlation of r=0.79, the single support time as well as the double support time both showed an excellent correlation of r=0.91 while these three were also significant at P<0.05. All the other selected temporal and spatial gait parameters showed a weak correlation with r<0.30 as well as showing varying significance.*

Conclusion: *This study has shown the GAITrite system to be reliable in assessing three of the twelve selected parameters of gait namely heel to heel base of support, single support time and double support time while demonstrating a poor reliability in the other selected parameters of gait.*

Introduction

Assessment of human movement is complex, and as such various techniques has been employed for this purpose such as stopwatches (1), paper walkways (2), visual observation (3) (4) and many more with most lacking in validity and reliability. With the ever-increasing influence of technology there have also been advances in the possibilities for the quantification of gait. The GAITRite® system, the cliinical stride Analyser, the Optogait gait analysing system are among recent tools used in assessment and analysis of gait (5).

The GAITRite® system is made up of a portable walkway embedded with pressure-activated sensors. These pressure sensors usually detect footprints when a subject walk over the mat. The system also has software which gathers information from the pressure activated sensors. This information is used to calculate numerous temporo-spatial gait parameters including but not limited to base of support, cadence, walking speed, step length, cycle time, toe in and toe out.

There have been a number of studies conducted to assess the validity of this system in comparison with existing techniques. A study by McDonough, et al., assessed the concurrent validity of the GAITRite® as opposed to chalk footsteps and hand held stopwatch. The result of the study demonstrates a high agreement of the chalk footprint with the GAITRite® system but less with the stopwatch (6). In another study conducted by Bilney, et al., a very high correlation was reported between the GAITRite® system and the Clinical Stride Analyzer®, concluding that the GAITRite® is valid for gait analysis (7).

Although the validity of the GAITRite® system has received much attention, there has been limited research on the reliability of this system. Most studies performed on the reliability of this system involved a small number of participants. A study conducted by van Uden, et al., as well as a study conducted by Menz, et al., used a small number of participants of 20 and 30 participants respectively (8) (9). Furthermore, values of spatial and temporal parameters of gait are regularly used to set baseline and determine appropriate therapy as well as to make diagnoses, identify gait deviations and monitor the progress of patients (9). Other reliability studies that have been performed with the GAITRite® system have been mostly on unhealthy individuals primarily on neurological patients (10) (11) . The goal of this study is to evaluate the test-retest reliability of the GAITRite® system on healthy young adults. The research question of this study is therefore ‘what is the test-retest reliability of the GAITRite® system on healthy first year physiotherapy students at the Hanze university of Applied sciences?

Method

Research population

A total number of 179 subjects participated in this study with an age range between 18 and 28. The subjects were first year physiotherapy Students at the Hanze University of Applied Sciences. The subjects had a lecture planned at the Hanze Active Aging Laboratory (HAAL) with focus on gait. For this lecture, walking on the GAITRite® was one of the activities that had to be performed. The subjects were asked to sign an informed consent if they were willing to participate in the research after reading the information

letter. A good understanding of Dutch and English was necessary for participation in this study since the lectures and instructions were in Dutch whereas the informed consent and information letter were in English. Ethical testing protocol was followed and there was no Medical Research (Human Subject) Act (WMO) testing required. There were inclusion and exclusion criteria for participating in this study and this is shown in table 1 below.

Table 1

Inclusion criteria	Exclusion criteria
First year physiotherapy students	Injury to the lower extremity
Age range between 18-40	Non- first year students' physiotherapy students
All races	

Research design:

The testing of the participants was performed at The Hanze Active Ageing Laboratory (HAAL), at the Wiebenga-complex of the Hanze University of Applied Sciences Groningen. The GAITRite® mat was set up in the HAAL. It was positioned in such a way that there was a 6-meter distance before the mat to enable the participants to accelerate to normal walking speed. There was also a 3-meter distance after the mat for the participants to decelerate. Two cones were placed at the starting point and two more at the ending point. A mark was made on the wall opposite the starting point which acted as a focus point while walking across the mat. The participants were instructed to focus on that point while walking. This was done to standardize the protocol and minimize distractions as other participants were also present in the room during the testing. The participants were also required to provide extra information such as age, sex, weight, height and leg length. The weight and height were measured using the provided weighing scale and a tape measure placed against the wall respectively. The leg length was measured by the researcher using a measuring tape from the greater trochanter of the right leg to the floor along the lateral malleolus. All measurements were made without shoes.

After getting all the instructions and providing additional information such as leg length, height and body weight, the participants were given a standard instruction to remove their shoes, take a standing position at the starting point, and asked to focus on the mark on the other side of the wall: they had to start walking when they heard the command 'GO'. The participants walked twice in quick succession on the walkway. The data was collected using a computer connected to the walkway system.

Measurement instrument

The GAITRite® system (GAITRite® Gold, CIR systems, New Jersey, USA) was used to assess the spatial and temporal parameters of gait. The Gaitrite system is a pressure-sensored electronic walkways system connected to a computer through an interface cable. The walk way is usually activated when pressure Is exerted on it. The overall dimension of the walkway is 90cm x 700cm with an active area of 60.96cm x 609.6 cm, sampling at a frequency of 80Hz. The GAITRite® system is one of the most recent devices used to measure temporal and spatial gait parameters. There have been studies performed evaluating the validity (7). (6) as well as various types of reliability of the GAITRite® system (12) (9).

Statistical Analysis

The collected data was saved in the GAITRite® system and exported into SPSS using excel. The analyses of the data were done using statistical software; the IBM SPSS version 23. Descriptive statistics were performed to determine the characteristics of the study population, whereas the normality of the data was determined using a probability-probability plot (P-P plot). Twelve temporal and spatial gait parameters were evaluated in this study including velocity, cadence, step time, step length, cycle time, stride length, swing time, stance time, toe in/toe out, heel to heel base of support, single support time and double support time. A paired T-test was used to assess the test-retest reliability of the selected variables. The choice for this test was made because the data were dependent measures, measured at interval level and normally distributed therefore meeting the assumptions of a parametric and a paired T-test (13) (14). The value of the Pearson's correlation coefficient (*r*) was used to determine the level of correlation while the P-value was used to determine the level of significance (14).

Result

Population characteristics

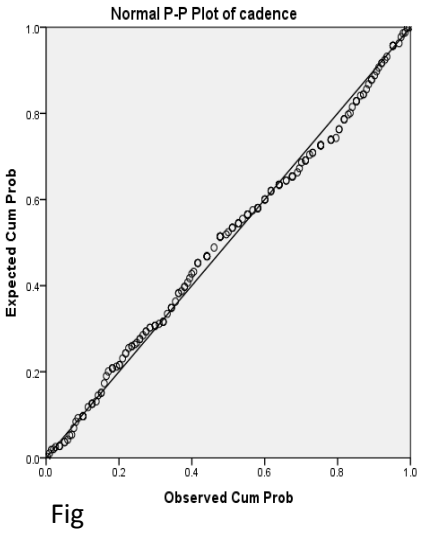
Table 2 below, illustrates the population characteristics of the study population. A total number of 179 students participated in this study of which 74 were male and 105 were females. The mean age of the population was 20 with a range of 10.

Table 2: population characteristics

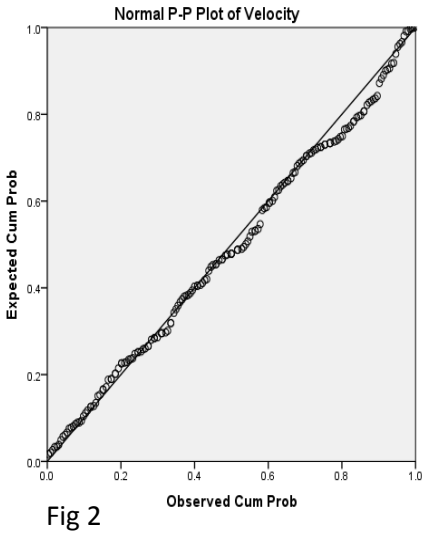
n: 179	Mean (SD)	Range: Min-Max		Percentage
Age	20 (2.0)	18-28		
Weight	71 (10.5)	45-109		
Height	174 (9.1)	157-200		
Leg length	90.5 (6.0)	77-106		
Gender: m/f			74/105	41.3/58.7

Test for normality

The figures below figure 1,2,3,4,5 and 6 shows the p-p plot of some of the selected temporal and spatial gait parameters, illustrating a normal distribution of the data.



Fig



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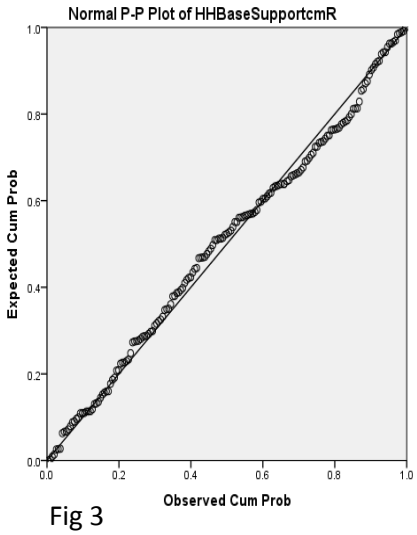

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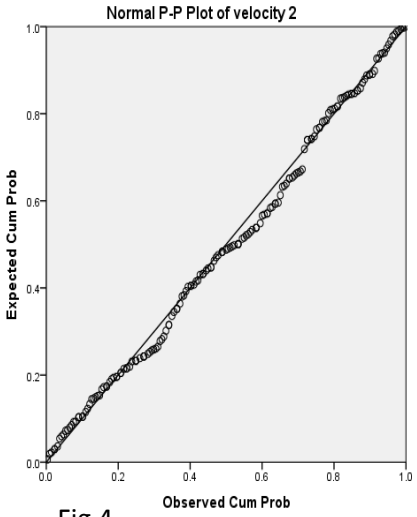

Fig 4

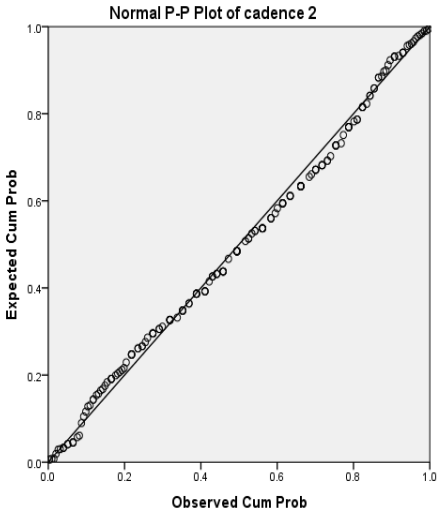

Fig 5

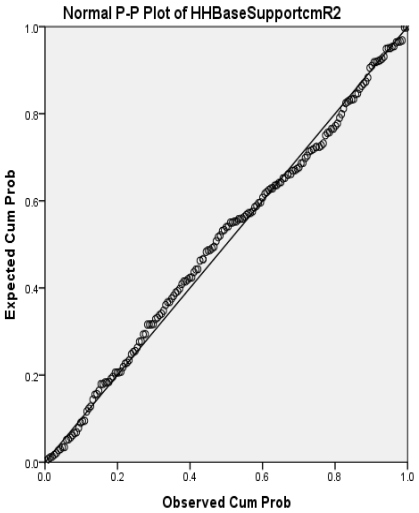

Fig 6

Test-retest reliability

Table 3 and 4 below shows the 12-selected and evaluated temporal and spatial gait parameters. While table 5, shows the temporal and spatial gait parameters that demonstrated high correlation and were significant.

As shown in table 3 below, two temporal gait parameters showed excellent correlation. The single support time and the double support time both showed excellent correlation of *r>0.91.* All the other selected temporal gait parameters showed a weak correlation with r<0.30. Furthermore, with regards to statistical significance; velocity, step time right, cycle time right, swing time left, stance time left, single support time and double support time were significant at *P<0.05* while cadence, step time left, cycle time left, swing time right and stance time right were not significant at *P>0.05.*

Table 3: All temporal variables with means, standard deviations, correlations and significance

Variables	Test 1 Mean(SD)	Test 2 Mean(SD)	Mean diff (SD)	95% CI of the difference	Correlation	Sig.
Velocity (cm/s)	159.5(18.2)	158.3(15.7)	1.1881(20.49)	-1.835-4.211	.276	<0.001
Cadence (steps/min)	123.0(7.8)	122.7(6.8)	0.3592(9.60)	-1.057-1.776	.141	.059
Step Time(sec) L	.491(.032)	.492(.029)	-0.0016(0.04)	-0.007-0.004	.125	.096
Step Time(sec) R	.489(.031)	.489(.028)	-0.0003 (0.04)	-0.006-0.005	.163	.029
Cycle Time(sec) L	.979(.062)	.981(.055)	-0.0018 (0.08)	-0.013-0.010	.144	.055
Cycle Time(sec) R	.980(.063)	.983(.055)	-0.0023 (0.08)	-0.014-0.009	.149	.047
Swing Time(sec) L	.397(.022)	.397(.021)	-0.0003 (0.03)	-0.005-0.004	.053	.479
Swing Time(sec) R	.396(.022)	.396(.022)	-0.0004 (0.03)	-0.005-0.004	.142	.058
Stance Time(sec) L	.583(.045)	.584(.039)	-0.0015 (0.05)	-0.009-0.007	.158	.034
Stance Time(sec) R	.584(.045)	.586(.039)	-0.0019 (0.06)	-0.010-0.006	.123	.100
Single support time (sec) L	.395(.021)	.397(.022)	-0.0014 (0.01)	-0.003-0.000	**.906**	**<0.001**
Single support time (sec) R	.397(.022)	.398(.022)	-0.0007 (0.01)	-0.002-0.001	**.906**	**<0.001**
Double support time (sec) L	.186(.031)	.192(.031)	-0.0059 (0.01)	-0.008-(-0.004)	**.913**	**<0.001**
Double support time (sec) R	.187(.031)	.192(.031)	-0.0056 (0.01)	-0.007-(-0.004)	**.913**	**<0.001**

* L: left, R: Right, diff: difference, SD: standard deviation

Similarly, as demonstrated in table 4 below, one of the four selected spatial gait parameters showed strong correlation. The heel to heel base of support showed a strong correlation of *r=0.79.* The other spatial gait parameters showed a weak correlation with r<0.30. Regarding the statistical significance; step length left and right, stride length left and right, toe in/toe out right, heel to heel base of support right and left were significant at *P<0.05* while toe in/ toe out left was the only spatial gait parameter that was not significant at *P>0.05.*

Table 4: All Spatial variables with means, standard deviations, correlations and significance

Variables	Test 1 Mean(SD)	Test 2 Mean(SD)	Mean diff (SD)	95% CI of the difference	Correlation	Sig.
Step Length(cm) L	77.73(7.0)	77.42(6.8)	0.3069 (8.74)	-0.981-1.595	.205	.006
Step Length(cm) R	77.77(7.0)	77.50(6.8)	0.2781(8.27)	-0.942-1.498	.289	<0.001
Stride Length(cm) L	155.6(13.8)	154.9(13.4)	0.6157 (16.63)	-1.836-3.067	.254	.001
Stride Length(cm) R	155.6(13.9)	155.1(13.5)	0.5698(16.71)	-1.896-3.035	.256	.001
Toe In / Out L (degrees)	.146(5.6)	.045(5.3)	0.1006 (7.29)	-0.975-1.176	.101	.178
Toe In / Out R (degrees)	1.685(5.1)	1.761(5.4)	-0.0754 (6.57)	-1.044-0.893	.222	.003
HH Base of Support(cm) L	9.094(2.3)	8.991(2.8)	0.1039 (1.78)	-0.158-0.366	**.791**	**<0.001**
HH Base of Support(cm) R	9.236(2.7)	9.212(2.9)	0.0233 (1.80)	-0.242-(-0.289)	**.791**	**<0.001**

* L: left, R: Right, diff: difference, SD: standard deviation, HH: heel to heel

As illustrated in table 5 below, three temporal and spatial gait parameters showed strong to excellent correlation. The heel to heel base of support showed a strong correlation of *r=0.79* while the single support time and the double support time both showed an excellent correlation of *r>0.90.* These temporal and spatial gait parameters were also highly significant at p<0.001.

Table 5: Selected temporal and spatial variables with strong to excellent correlation and significant

Variables	Test 1 Mean(SD)	Test 2 Mean(SD)	Mean diff (SD)	95% CI of the difference	Correlation	Sig.
HH Base of Support(cm) L	9.094(2.3)	8.991(2.8)	0.1039 (1.78)	-0.158-0.366	**.791**	**<0.001**
HH Base of Support(cm) R	9.236(2.7)	9.212(2.9)	0.0233 (1.80)	-0.242-(-0.289)	**.791**	**<0.001**
Single support time (sec) L	.395(.021)	.397(.022)	-0.0014 (0.01)	-0.003-0.000	**.906**	**<0.001**
Single support time (sec) R	.397(.022)	.398(.022)	-0.0007 (0.01)	-0.002-0.001	**.906**	**<0.001**
Double support time (sec) L	.186(.031)	.192(.031)	-0.0059 (0.01)	-0.008-(-0.004)	**.913**	**<0.001**
Double support time (sec) R	.187(.031)	.192(.031)	-0.0056 (0.01)	-0.007-(-0.004)	**.913**	**<0.001**

*L: left, R: Right, diff: difference, SD: standard deviation, HH: heel to heel

Discussion

Due to the continued use of the GAITRite® system in clinical practice to measure variations in temporal and spatial gait patterns, it was paramount to assess the test-retest reliability of the system. The purpose of this research was to evaluate what the test-retest reliability of the GAITRite® system is, on healthy first year physiotherapy students at the Hanze university of Applied sciences. The result of this study shows a strong to excellent correlation in three of the selected gait parameters namely; heel to heel base of support at r=0.79, single support time and double support time both at r=0.91. These three mentioned gait parameters showed strong to excellent correlations and were as well significant a $p<0.05$ showing a good test-retest reliability. The other gait parameters demonstrated weak correlation at $r<0.3$ and varying significance at $p>0.05$ indicating a poor test-retest reliability. It is however important to note the difference in significance between the temporal and the spatial gait parameters. All spatial gait parameters except toe/toe out left were all significant at $p<0.05$ while of temporal gait parameters; cadence, step time left, cycle time left, swing time left and stance time right were all not significant at $P>0.05$.

The number of healthy subjects that participated in this study which amounted to a total of 179 is one of the major strengths of this study. Other studies of this nature conducted on healthy participants were performed with fewer participants. A study by van Uden, et al., with a total of 20 participants showed a high ICC of 0.79 and higher and a study by Menz, et al., with 30 participants showed a high ICC between 0.81-0.91 with the exception of the base of support which showed a fair ICC of 0.49-0.56 left and right respectively (8) (9). Menz, et al., however suggests that the high ICC obtained may have been due to a high range of scores in the samples. There have also been reliability studies performed with the GAITRite® system on unhealthy patients with most of them being on patients with neurological impairment including stroke patients (12) (15), Parkinson patients (16) and patients with multiple sclerosis (17) among others. These studies were also conducted with low to moderate number of participants ranging from 20 to 106. The results obtained from the studies above do however differ from the results of this study; where most gait parameters showed poor correlation except for the heel to heel base of support, the single and the double support time. This could be attributed to the variations in the design of the studies with some assessing the inter and intra-rater reliability, using an interclass correlation coefficient to calculate the correlation. Another strength of this study is the test environment which was created such that other students were within the room when the participant was performing the test. This was done to create as much of a natural environment as possible since people seldom walk in a quiet environment.

Despite the strengths of this study, there were some limitations with the first being the age range of the participants. The age range of the participants was considerably small at a range of 10 (18-28) and this does not provide enough variation which could hamper the generalizability of this study. Other studies of this nature have been performed with larger age range and this might have had an influence on their outcomes. Furthermore, the participants of this study were not familiar with the GAITRite® system and this might have influenced the measurement during this study. Although the researcher demonstrated how the system works and gave clear instruction, it might have been more standardized to give each participant a trial run before the main measurement.

The subjects of this study generally walked at a higher cadence and cycle time than normal. The normal cadence and walking time as described by (18) are an average of 113 steps/min for men and 118 step/min for women. The cadence of the participants was at a mean of 122 and 123 for the first and second walk respectively involving both gender. However, their cycle time left and right for both walks were 0.98 which was below the average norm of 1.06 for men and 1.02 for women (18).

Although it is possible to objectify various temporal and spatial parameters of gait using the GAITRite® system, it is however necessary to be critical in the use of the system in clinical practice in a test retest situation. It is important to consider giving trial runs to subjects being evaluated using the GAITRite® system especially if it is their first time using the system. Gait parameter varies with age, for this reason it would be recommended that further research be performed with greater age range as well as a similar or bigger population size. This will provide a better stand point for generalization of the result.

Conclusion

This study has shown that the GAITRite® system is reliable instrument for assessing parameters of gait such as heel to heel base of support, single support time and double support time in a test-retest situation. However, it has a low test-retest reliability for other parameters of gait namely velocity, cadence, step time, step length, cycle time, stride length, swing time, stance time, toe in/toe out. Due to the variation of Gait parameters with age, it would be recommended that future researches be conducted with higher age range and comparable or higher population size.

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Appendix 1. Information letter

Information letter

Research question

what is the test retest reliability of the GAITRite® system on healthy first year physiotherapy students at the Hanze University of Applied Sciences?

Background information.

The GAITRite System is an electronic walkway, this walk way sytem contains pressure activated sensors which measures various parameters relating to gait. As a subject walks across the walkway, the pressure exerted by the feet onto the walkway activates the sensors. The walkway does not only sense the position of the feet but also the relative arrangement between them in a two dimensional space. Considering the continued use of this system not only in analysing the parameters of gait but also sometimes in prognosis of certain conditions, the focus and aim of this research is in determining the reliability of this system in a test-retest situation on healthy adults.

What is expected of the participant

It is expected that in the research the participant will be available for the total time of the measurement which is approximately 20 minutes per subject. The participant is also expected to fill in the informed consent form and follow the instructions given by the researcher as precise as possible during the measurement.

Important to know

It is important for the participant to realize that the personal information obtained with regards to this research will be treated with optimum confidentiality.

Additional information

For the purpose of this research, if you have questions or want to know more, you can contact the persons listed below

Ogbonna Ebeke
o.j.ebeke@st.hanze.nl
0687401990

Hans van de Leur
j.p.van.de.leur@pl.hanze.nl

Appendix 2. Informed consent

Informed Consent Form.

School of Health Care Studies, Hanze university of Applied sciences Groningen

Research question: what is the test retest reliability of the GAITRite® system on healthy first year physiotherapy students at the Hanze University of Applied Sciences?

I have read the information letter for the participants of this research. I have asked the questions I deem necessary in relation to participating in this research and my question have been adequately attended to.

I am aware that participation in this research is voluntary and that I have the freedom to withdraw my participation in this research when I deem it inconvenient.

I am aware that the researcher has access to the information I have provided for the purpose of this research. I however give approval for the use of those information for the purpose of this research as stated in the information letter.

I am willing to participate in this research

Name of participant

Signature: Date: __ / __ / __

I declare hereby that I have sufficiently informed this participant about this research.

The participant will be made aware of any necessary information concerning him/her that may arise during the process of this research.

Name of Researcher

Signature: Date: __ / __ / __

Appendix 3. Extra information

Extra Information

Age:

Sex: male □ female □

Weight:

Height:

Leg length:

Name: .....

Appendix 4. Medical Research (Human Subject) Act (WMO)