Fontys Paramedic University of Applied Sciences, Eindhoven

Department of Physiotherapy, English Stream

Test-Retest Reliability Of The Interactive Training Software Neuromuscular Control Tests Using The Sensbalance MiniBoard In Healthy Young Adults

Experimental Study

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Preface

I would like to thank everyone who supported and motivated me throughout my writing and experimental process. Special thanks go to my supervisor Leteke Vos-Slaats and assessor Annelies Simons who gave me their time and attention within the last months by assisting me with great clues. Thank you for your patience and efforts! Aside thanks is applied to my colleagues and acquaintances for the cooperation and feedback they provided me with. Furthermore, I appreciate the participation of all the voluntary students taking part in my experiment. Thank you. And not to forgive my adorable family from Germany: without their attendance and endeavour I would not come up with this proud final product.

This 4th year practice-based research is one of my last steps to become a physiotherapist. The topic was chosen voluntarily from a predetermined list published by the Fontys University of Applied Sciences in summer 2014. It was my first choice when I started to decide about what domain I would like to write my bachelor thesis.

In my home country Germany I practiced gymnastics for several years. When I was older I taught it to little kids. I enjoyed this kind of sport: the way of moving, the elegance, expression and preciseness. Gymnastics requires proper muscles strength, flexibility, coordination, control and not to forgive balance. Without a proper balance I would not have performed as I did. But for what else do we require balance? Is it for my grandmother as important as it was for me when doing gymnastics? It is for everyone. The challenge may be different within the individual but an adequate balance is vital for people of all ages. But what happens if balance is impaired? We have troubles to manage daily activities and not to speak of performing our gymnastic exercises.

I had a very interesting patient during my last internship. The reason why she visited our practice was her disturbance in balance. Her main concern was the crossing of a street: she was afraid to stumble and getting involved in troubles. She made a very attentive and active impression towards me. I showed her lots of exercises and gave her advices regarding daily activities. One tool we used in the sessions was a wobble board: she liked this way of exercising. I chose several types which varied in task and difficulty. After ten demanding, instructive and successful meetings using amongst other this balance tool, she left our practice as a more self-confident and secure woman.

Physiotherapists see lots of patients in whose situations a balance assessment and training is indicative. But to gather the right information, make correct interpretation of them and chose an appropriate treatment plan, we require tools that deliver those reliable data and are recommended to work with. Working as a physiotherapist requires knowledge and expertise as it is asked from a tool we use. Therefore, I took a device, similar to a wobble board, and tested its quality criteria.

Now I would like to share with you my knowledge and experiences I gained while conducting this study.

Anneke Klostermann

Abstract

Introduction

Assessment and training of balance skills is a domain in physiotherapy and physiotherapists have a great supply of tools for that, like posturography. Investigators, however, revealed disadvantages like being expensive or inaccurate. The Sensbalance MiniBoard with interactive training software Neuromuscular Control (NMC) tests was introduced in this study as an alternative. It consisted of a wobble board, connected with a laptop on which the software was installed. Sensors integrated in the board registered movements made on it. The tool tested static and dynamic balance. However, it has not yet been examined on its quality criteria.

Aim

Aims were the evaluation of the test-retest reliability of the Sensbalance MiniBoard with the interactive training software NMC tests and the capture of reference values.

Method

In this experimental study, conducted in October 2014, participants performed two static and five dynamic balance exercises on the MiniBoard and repeated those two weeks later. MiniBoard movements corresponded with a red ball that left green trajectories on the screen. The variables angle tilt, staying and deviating with the ball from given figures shown on the monitor and the overall performance were recorded. Results from both testing phases were compared, intraclass correlation coefficients calculated and reference values generated.

Results

Thirty three students (16 females; 17 males) participated. On average the subjects scored better on the initial test. Intraclass correlation coefficients for each outcome variable ranged from 0.11 to 0.77. The reference values for the overall performance in percentage in each NMC test were categorized on a scale representing a good, medium or poor balance.

Conclusion

The test-retest analysis within this study showed that the balance tool did not give stable measurements. The researcher recommends using the tool only in combination with others, but benefits, such as being user-friendly and challenging, convince its application in therapy.

Key words: balance, balance board, wobble board, assessment tools, reliability, intraclass correlation coefficient, lower extremities

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1. Introduction

Balance is a state in which the weight is equally distributed over the body in order to let the human being stay or sit upright and steady.[1-2] The centre of gravity (CoG) defines the point where the whole body mass is concentrated and the base of support (BoS) is the contact point of the body and a surface. The CoG is in stance relatively high and broader whereas the BoS is respectively smaller. If the line of gravity, the perpendicular from the CoG down the surface, does not fall within the BoS, balance will be disturbed for this moment. The human will even fall if non adjustment is made: for example by taking a step forward which brings the line of gravity back within the BoS and controls the posture.[1] Shumway-Cook et al.[3] describe balance as being able *"to control the centre of mass in relationship to the base of support".*[3 (p.158)]
Many activities require an appropriate static or dynamic balance. Static balance is defined as having the CoG under control when the BoS is stable[4], such as standing[5]. Dynamic balance describes the skill to shift one's CoG within the BoS[4], for example during walking[5]. Having a proper balance depends on the interaction of complex sensorimotor systems working together. A sensory input comes from the visual, vestibular and somatosensory system, after its integration by the brain, a motor output is given to muscles and joints.[6] The overall system must be constantly in action for its adjustment in order to achieve, maintain or restore balance during any postural or activity related change.[7]
The ability of keeping balance, also described as a motor skill[1], can be disturbed within persons due to the aging process or any pathology (neurological like Parkinson's disease or musculoskeletal such as ankle sprain).[6-7] Therefore, there is a wide range of reasons for which individuals might need diagnostic or therapeutic interventions regarding their balance abilities.

A physiotherapist can evaluate the balance which provides information about the patient's functional and activity related state, gives proper insight in possible participation limitations as well as supports in the diagnostic and therapeutic process.[4,7] In clinical settings there are various ways to assess balance abilities ranging from questionnaires, performance tests, to instrumented tools like posturography.[7] To reduce subjectivity and bias, a physiotherapist should prefer to use an objective measurement tool.[8] In general, reliability of any clinical assessment tool is important to provide a firm evidence base and ensure that the used measurement tool is trustful and reinforces outcomes. It needs to be both repeatable and reproducible[9]. Researchers aim to find measurement tools which are amongst others inexpensive, user-optimised, movable as well as reliable and provide overall accurate information.[8,10]

Thus, studies investigated the quality criteria of balance tools and detected amongst others that some tools are expensive[10], not available in clinical settings[11] and/or specialized on a patient group having a particular age and/or impairment[7]. Moreover, instrumental tests, like computer-based tools, are more expensive and complex but often represented as an appliance suitable for a wider range of people and being more precise and objective.[12] In addition, their settings can be adjusted to the individual's characteristics and goals.

Wobble boards, with uneven and sensory-stimulating surfaces, seesaw-like lever or circular[13], are commonly used in physiotherapeutic facilities but so far mostly related to training.[14] Along, they have a positive effect on proprioception which is strongly linked to balance. Wobble boards can be used by a

variety of people: by older people helping them to maintain the awareness of balance control and prevent the risk of falling or by athletes being useful to treat, for instance, ankle sprains.[15,16]
Likewise, the Sensbalance MiniBoard from Sensamove® (see Figure 1) is a computer based wobble board comparable to the Wii Balance Board (WBB). Researchers gained excellent intra-rater and inter-rater reliability when testing the WBB.[10]

Sensamove® states that the Sensbalance MiniBoard is a cost-effective, portable and user-friendly tool. Moreover, that it represents an equipment that can be used to train but also to test balance abilities. One of the software programs is the interactive training software Neuromuscular Control (NMC) test, which includes two static and five dynamic balance exercises.[17] The outcome variables within each test measure different aspects related to balance, like the amount of tilting the MiniBoard, and results give an insight into the user's balance capacities. So far there is no evidence about the test-retest reliability of this combined balance tool to determine its utilization in clinical settings. Moreover, reference values are missing to evaluate and compare NMC test results.

Therefore, the main purpose of this practice-based research is the investigation of the test-retest reliability with the establishment of protocols for all seven NMC tests. The gathered outcome variables can provide reference data. Results can give recommendations about the use of the MiniBoard with the NMC test software within a healthy population. The equipment might have advantages in physiotherapy and can have clinical relevance in both assessment and training of patients with balance interferences.
Consequently, the following research questions were stated:

What is the test-retest reliability of the interactive training software NMC using the Sensbalance MiniBoard in healthy young adults? What are normative reference values for the seven NMC tests for this particular group?

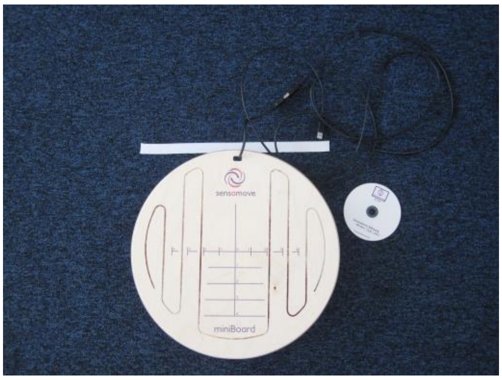


Figure 1: Equipment from Sensamove®

2. Methods

2.1 Study Design

This study was an experiment investigating the test-retest reliability of the NMC tests using the Sensbalance MiniBoard from Sensamove®. It was performed in collaboration with Fontys Paramedic University of Applied Sciences in Eindhoven, the Netherlands and Geert Jan Dijkstra, Chief Executive Officer of Sensamove® in Utrecht. The testing took place in a practical room of the Fontys University Building TF at Theodor Fliednerstraat.

2.2 Participants and Sampling

For this practice-based research all English Stream students from the Fontys University of Applied Sciences Eindhoven were recruited. The students were contacted and invited to participate in this project on a voluntary basis via the mailing list of Fontys University and also via personal contact (see Appendix I). Detailed information about the research project and requirements for participation were given to them (see Appendix II). Table 1 show the inclusion and exclusion criteria which were also stated in the information letter in order to gather the right population for this study. If at least one exclusion criteria was applied, the person was excluded; for inclusion all criteria needed to be fulfilled. All suitable persons were tested on the MiniBoard individually and then retested two weeks later by the same assessor for the test-retest reliability analysis.

Table 1: Inclusion and exclusion criteria for participation

Inclusion	Exclusion
• English Stream student at Fontys University of Applied Sciences	• diagnosed with any kind of balance disorder (like benign paroxysmal positional vertigo (BPPV) or Meniere's disease)
• being at least eighteen years old to be authorized to participate and sign	• currently diagnosed with a major medical condition (such as neurological disorder or infectious disease) which can be a risk for measurement
• being able to communicate in English	• suffering from any pathological, abnormal health condition which could influence balance (e.g. ear infections, blood pressure changes)
• being free from any (severe) injury of the back, hips, knees, ankles and/or feet six months prior to participation to make sure that the tasks can be performed safely	• having regular symptoms like dizziness, blurred vision, light-headedness, faintness, disorientation, nausea/ vomiting, and/ or having troubles with sleeping/ concentration
• being free from any medication intake which could have an effect on balance	• vision being impaired which cannot be solved with glasses/ contact lenses
	• students performing any physical activity >5 times per week on a competitive level which could give a competitive edge opposite to other participants

2.3 Survey Instruments

The equipment of Sensamove® consisted of the Compact Disc Read-Only Memory (CD-ROM) with the optional software NMC tests (version 2.3) which was installed on the laptop (Acer® Aspire V5); a standard Universal Serial Bus (USB) cable to connect it with the laptop; and the Sensbalance MiniBoard (made of wood, diameter: 40cm/15.7 inches). The board, which had integrated sensors, registered the tilts made by the person standing on it with both feet. One of the exchangeable rubber accessories, which are placed via a magnetic click-on system under the board, was chosen. The purple accessory, which allowed a tilting of approximately 15° in all directions, was applied. It was chosen, because it was assumed after the pilot testing that this type is suitable for the majority of this study group. The measuring instrument of the Fontys Lab, Jenix® model DS-103 Jenix®, detected the length and weight of the participants. For the time specification, which was needed to check adherence to the time limit set up for each procedure of testing, a watch (CRIVIT® 1-LD3473-2) was used. A digital camera (Canon® Digital IXUS 100 IS) recorded the subject's feet positioning on the board.

For the testing days the board was placed on an ordinary, antislip floor surface[16] in a correct direction towards the screen of the laptop. The recommended distance between eyes and monitor ranges between 40 to 76 centimetres, the top of the monitor advised to be tilted by 10-20 degrees.[18] Therefore, the board stood within this distance to the table where the laptop was placed on and the monitor was tilted according to the recommendations mentioned above. All the other needed materials were put within reach to the device: chairs in case the subject needed to sit down while resting, the watch, tapes to mark the exact feet positioning, the camera and writing materials. (see Figure 2)

Figure 2: Testing conditions

Figure 3: Tape marking

2.4 Research Procedure

On the first testing day the participant was personally introduced to the project, followed by a detailed explanation about the experiment (goal, procedure, time, risks) by the researcher. After clarifying the eligibility and unanswered questions from the invitation and information letter, the researcher ensured that the subject did not take any medications, was free from any injury, disease or symptoms that could affect the balance abilities and been a risk factor for the performances. The participant was asked to sign the informed consent (see Appendix III) in order to start with the experiment.

The performance of the exercises, administered according to the standardized protocols (see Appendix IV) made by the researcher, needed to be explained and the feet positioning on the board identified. Before the first testing took place, there was an implementation phase about five minutes, in which the participant explored each task for 30 seconds to get familiar with the equipment and to find out the best feet positioning. A photo was taken and tape applied on the board to ensure consistent left and right foot placement on both testing days: one stripe behind the subject's heels, another in front of the great toes and a third on the medial sides of the feet (see Figure 3).

The procedures described in the following were executed in a consistent method in both testing weeks: the researcher strived to keep the conditions for the single days similar, including the surrounding where the testing was conducted and timing and built up of materials used. Each single testing lasted 30 minutes. The participant stood barefoot[16] on the board with respect to the tape; both knees slightly bended avoiding hyperextension and the arms hung next to the body, free to move. During the testing the assessor ensured security and chose the required exercise after each other. According to the pilot testing done before, each task lasted 60 seconds; there was a stopwatch on the screen clearly visible for the user. Goal of the exercises was to perform as best as possible and not time dependent. Therefore, the speeds of movements were chosen by the participant. The subject was challenged to touch the ground with the edges of the board as less as possible to avoid relief. A resting period (maximum three minutes) adjusted to the subject's need was given between each sub-test. The participant recovered and prepared for the next task, while the assessor saved the results and changed the exercise. For each task, except for the first static balance test without visual feedback, there was a red ball seen on the screen of the laptop. The sensors inside the board signalled the tilting angle of the MiniBoard which represented this red ball. If the MiniBoard was not tilted towards any direction (tilt angle 00.0°), the ball was totally still and perfect balance was achieved. Each task started from a neutral position (angle 00.0°) with the ball centred in the disk seen on the laptop's screen. The assessor needed to calibrate the board before each task. The balance measurement with the functional related equipment involved seven NMC tests: two static and five dynamic balance tasks (see Table 2 and Appendix IV).

Because they had different levels of difficulty, the order of the tasks was randomised to the subjects using a random sequence generator[19] (see Appendix V). To minimize bias the individual had the exact same order on both testing days. The order was recorded in the data collection table (see Table 3).

2.5 Data Collection

Prior to testing, each participant completed in the presence of the researcher a self-administered standardized questionnaire developed by the researcher (see Appendix VI). Sociodemographic information was assessed by questions about age and gender; individual characteristics by asking about the shoe size and physical activity level per week, as well as additionally questions to investigate eligibility for the experiment. The researcher measured the length (in cm) and weight (in kg) of each individual in the Fontys Lab. (see Table 3). After testing, the researcher asked each individual for the subjective experience about the exercises by requesting to point out which task was the most easy and most difficult one. The data, used in the analyses, were written down in the data collection table (see Table 3 and Appendix VII), saved on the software and entered in excel on the laptop according to the subject's name.

As soon as one test was completed by the subject, the training software NMC reported the movement trajectories and stored them individually in the subject's database and as a Portable Document Format (PDF) on the laptop (see Appendix VIII). The behaviour for moving more or less frequent in certain directions was analysed and reported. The full trajectory was presented by a graph and outcome variables were shown. In Table 2 the variables of the NMC tests that were used in this research project for the analysis can be seen. The variable "overall performance" (1^{st} – 7^{th} NMC tasks) in percentage ranging from the minimum 00.0%, which described bad balances skills, to the maximum 100.0%, which represented excellent balance skills, were given. The “overall performance” was only stated as a whole number and main focus was put on this variable because it was measured unitary in all seven NMC tests and gave a general insight into balance abilities. The variable average “angle tilt” (1st - 4th NMC tasks) with the MiniBoard to the front, back, left and right side was presented in degrees. The variable average magnitude “staying inside” the figure front and back (3rd task) as well as left and right (4th task) in percentage from 00.0% - 100.0% and the amount of the variable “deviating from” (6th task) the path towards the inside and outside in percentage from 00.0% - 100.0% were given. The fewer the MiniBoard was tilted to any direction, the longer the subject stayed within the given figure and the less the subjects deviated from the path with the red ball, the better the balance skills were.

Table 2: NMC tests overview

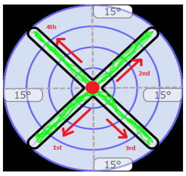
Name of NMC Test	Assignment of Task	Outcome variables
balance with visual feedback (1st)	standing as still as possible on the board, keeping the red ball visible on the screen centred	performance in percentage (min.0%, max.100%) angle tilt front, back, left, right in degrees (best 0°)
balance, proprioception without visual feedback (2nd)	standing as still as possible on the board	performance in percentage (min.0%,max.100%) angle tilt front, back, left, right in degrees (best 0°)
left-right (3rd)	moving on the board towards the left and right side alternative, so that the ball is moved within a given figure	performance in percentage (min.0%,max.100%) angle tilt front, back, left, right in degrees (best 0°) staying inside the figure front, back in percentage (worst 0%, best 100%)
front-back (4th)	moving from forward to backward alternative, so that the ball is moved within a given figure	performance in percentage (min.0%,max.100%) angle tilt front, back, left, right in degrees (best 0°) staying inside the figure left, right in percentage (worst 0%, best 100%)
cross-diagonal (5th)	moving in directions front-left, back-right, front-right, back-left, so the ball is moved within a given figure (see Figure 4)	performance in percentage (min.0%,max.100%)  **Figure 4:** cross-diagonal 5th task
donut (6th)	clockwise movements in a big circle	performance in percentage (min.0%,max.100%) deviating from the figure to the inside, outside in percentage (best 0%, worst 100%)
circle (7th)	clockwise movements in a small circle	performance in percentage (min.0%,max.100%)

Table 3: Data Collection, example from subject no.1*

Full Name Subject:	XXX*
Subject Number:	S1
Date of Birth:	04/07/1991
Gender:	Male
Length in cm:	190.4
Weight in kg:	88.4
Date 1st Testing:	15/10/2014
Date 2nd Testing:	29/10/2014
Individual results saved under:	1st Testing Day: C:\Users\Anneke\Documents\ Experiment 2014 1\ANNEKE\S1 2nd Testing Day: C:\Users\Anneke\Documents\ Experiment 2014 2\Anneke\S1
Sequence of tasks:	2 4 5 3 6 1 7
Subjective experience:	Most easy task: (1st testing phase) NMC 2; (2nd testing phase) NMC 7 Most difficult task: (1st testing phase) NMC 2; (2nd testing phase) NMC 6

*data held anonymous

2.6 Data Analysis

For normal distributed data the central tendency (mean) and the appropriate measure of dispersion (standard deviation (SD)) were calculated, for not-normal distributed data the median and interquartile range (IQR) 25% - 75%. Possible outliers were included in the analyses. The results of the outcome variables within the two static and five dynamic NMC tests were described. The variables in the NMC tests, which were in total 29, were the “overall performance” in percentage, the “angle tilt” in diverse directions in degrees and “staying inside” as well as “deviating from” the figures with the ball in several directions in percentage. The results of the first and second testing day were compared to each other which gave an impression of the difference between one test administration to the next.[20] Therefore, the difference between the mean respectively median values achieved in the outcome variables from both testing days was calculated. Positive values indicated an improvement, negative values a worsening. To establish test-retest reliability, a correlational analysis between the variables within the seven NMC tests from the initial test to the retest was done. The values attained with the seven tasks were analysed by defining the estimate of correlation and its 95% confidence intervals using the method described by Shrout and Fleiss[21] (two-way mixed, absolute agreement, single measures) as interclass correlation coefficient.[21] According to Cicchetti[22], values of 0.75 and higher indicate an excellent agreement, those between 0.74 to 0.60 a good agreement, 0.59 - 0.40 show only a fair agreement, and values <0.40 represent a poor agreement.[22] A minimum value of 0.80 is needed in order to speak about a reliable measurement tool.[11] Data were interpreted as statistically significant different when $p<0.05$.
The researcher gathered normative reference data from the “overall performance”, which was reported in each NMC test, for healthy young adults. For it, the original data, which were gained by the study group, were divided into good (100.0% - 76.0% quantile), medium (75.0% - 26.0% quantile) and poor (25.0% - 00.0% quantile) balance skills. These cut off points were created by analysing the mean of the quantiles from the initial test and retest. The numbers were rounded as the NMC tests only give percentage values without decimal. Both testing phases and their outcomes were applied in order to represent the average balance performances of the group. (see Appendix IX)
For the statistical analysis the Statistical Package for the Social Sciences (IBM SPSS Statistics 21) and Microsoft (MS) Excel (2010) were useful.

2.7 Ethical Paragraph

The requirements for participation were to sign the informed consent (see Appendix III) that was given to each participant on the first day of testing and thereby agree to the terms and conditions. By request, the participant got the individual result of the experiment. All data were kept and processed anonymously by the researcher and people involved in the study. The student and a representative of Fontys University of Applied Sciences were committed to maintain confidentiality of data (see Appendix X) and sign the conveyance of rights (see Appendix XI).

3. Results

Participants

In total 33 physiotherapy students (16 females (48.5%); 17 males (51.5%); median age in years 23) were included in the test-retest reliability assessment (see Table 4). No subject needed to be excluded because of any injury, disease or symptoms which could have affected the balance abilities. From the 33 participants, five (15.5%) were not involved in any physical activity on a regular basis, 16 (48.5%) did some kind of sport two to three times per week and twelve (36.4%) exercised more than four times a week but not on a competitive level. Including sports like football, handball, basketball, field hockey as well as strength training and cardio fitness like cycling and running.

Table 4: Sociodemographic and anthropometric data of test subjects

	N	Median	Quartile 25%	Quartile 75%
Age in years (n=33)	33	22.97	22.00	24.00
Length in cm (n=33)	33	173.80	166.40	183.35
Weight in kg (n=33)	33	71.40	62.55	86.90

NMC Tests

The NMC test results with respect to the median and IQRs of the first and second testing day as well as the calculated differences between those two measurement days can be found in Table 5 and for further details see Appendix XII. To summarize the subjective experiences of the study group, the first NMC test (balance) was the easiest to execute, and the seventh NMC test (circle) the most difficult. When looking at the median value of each measurement variable, it was observed that the study group performed on average higher on the first testing day than on the second. Results of the “overall performance” ranged from 20.0% to 96.0% when considering both testing phases and each individual result separated.

Static tests:

Overall best results were achieved in the **first** static NMC test (balance) on both measurement days. Additionally, minor changes in the balance abilities were seen in the first static NMC test balance if all measured variables and both testing days were considered. One of the measurement variables, the “overall performance”, was higher in the first static NMC test (balance) on the initial test (93.0%) than on the retest (92.0%), but the difference between the median values was small. With respect to the other outcome variable “angle tilt” to different directions, the subjects displaced the MiniBoard in any direction three out of possible four times to a lesser degree on the initial test compared to the retest in the first NMC task. The differences to values in the retest were kept small. Furthermore, the study group achieved a lower “overall performance” in the **second** static NMC test (proprioception) on the first day (88.0%) but it differed only little to the measurement variable of the second testing day (89.0%). The variables “angle tilts” were two out of four times fewer in the initial test and not far away from the values of the retest.

Dynamic tests:

In the **third** NMC test (left-right) the subjects achieved again a higher “overall performance” percentage on the initial test (48.0%) compared to the retest (41.0%). These two median values differed to a greater amount. All of the other possible six outcome variables, which were additionally measured to the “overall performance”, were scored better in the initial test. The distinction between the two measurement days was again slightly greater. Moreover, in the **fourth** NMC test (front-back) the participants accomplished better results (five out of possible seven measurement variables) on the first testing day. The variable “overall performance” percentage was with 54.0% better accomplished in the initial test than in the retest in which 53.0% was achieved. The differences between the median values of the other six outcome variables were bigger compared to previous stated results. With a small difference of 1.0% the subjects got in the **fifth** NMC test (cross-diagonal) on average a higher percentage on the initial test (47.0%) than on the retest (46.0%). Furthermore, when considering the **sixth** NMC test (donut) and the measurement variable “overall performance” same results were observed on both days (61.0%). The variable “deviation from” the given figure towards the inside was scored better in the retest, the other variable “deviation from” the figure towards the outside on the initial test. But the distinctions between those outcome variables were subtle. In the **seventh** and last NMC test (circle) the subjects performed better on the first testing day than on the second. The difference of this variable “overall performance” was small, 80.0% was achieved in the first testing week and 79.0% in the second.

Table 5: Descriptive Analysis NMC test variables from the 33 participants

Variable in percentage or degrees	**Initial test**		**Retest**		**Difference Initial test - Retest**
	median	**IQR (25 - 75%)**	**Median**	**IQR (25 - 75%)**	**median**
static tests					
balance 1st					
performance (%)	93.00	90.00 - 94.00	92.00	90.50 - 93.00	-1.00
front (°)	0.67	0.55 - 0.86	0.72	0.60 - 0.94	0.05
back (°)	0.72	0.59 - 1.11	0.87	0.64 - 1.07	0.15
left (°)	0.67	0.60 - 0.89	0.72	0.53 - 0.89	0.05
right (°)	0.65	0.55 - 0.82	0.65	0.58 - 0.82	0.00
balance, proprioception 2nd					
performance (%)	88.00	83.00 - 90.00	89.00	85.00 - 92.00	1.00
front (°)	0.75	0.44 - 1.21	0.85	0.57 - 1.27	0.10
back (°)	1.28	1.03 - 1.68	1.07	0.78 - 1.56	-0.21
left (°)	0.78	0.60 - 1.36	0.68	0.45 - 0.94	-0.10
right (°)	0.70	0.52 - 1.21	1.02	0.64 - 1.41	0.32
dynamic tests					
left-right 3rd					
performance (%)	48.00	41.50 - 54.00	41.00	36.50 - 51.50	-7.00
inside front (%)	22.00	19.50 - 27.50	20.00	17.00 - 24.00	-2.00
inside back (%)	25.00	22.00 - 30.00	21.00	18.50 - 24.50	-4.00
front (°)	1.26	1.08 - 1.44	1.48	1.18 - 1.68	0.22
back (°)	1.49	1.22 - 1.77	1.69	1.39 - 2.15	0.20
left (°)	6.72	5.49 - 7.74	7.44	6.14 - 9.16	0.72
right (°)	6.46	5.43 - 7.08	7.32	6.57 - 8.37	0.86
front-back 4th					
performance (%)	54.00	44.50 - 58.00	53.00	41.50 - 61.00	-1.00
inside left (%)	26.00	21.50 - 30.50	26.00	21.00 - 29.00	0.00
inside right (%)	27.00	23.00 - 29.5	25.00	21.00 - 31.50	-2.00
front (°)	6.24	5.50 - 7.74	7.46	6.49 - 8.53	1.22
back (°)	6.56	4.96 - 8.33	7.50	6.00 - 9.85	0.94
left (°)	1.32	1.10 - 1.58	1.28	0.98 - 1.51	-0.04
right (°)	1.24	0.98 - 1.48	1.31	1.04 - 1.72	0.07
cross-diagonal 5th					
performance (%)	47.00	39.50 - 52.00	46.00	36.50 - 51.00	-1.00
donut 6th					
performance (%)	61.00	56.00 - 68.00	61.00	58.00 - 66.00	0.00
deviation inside (%)	27.00	19.50 - 30.00	25.00	19.50 - 29.00	-2.00
deviation outside (%)	13.00	7.50 - 16.00	14.00	7.50 - 17.50	1.00
circle 7th					
performance (%)	80.00	73.00 - 85.00	79.00	68.00 - 85.00	-1.00

Table 6 shows the outcomes of the correlational analysis between the first and second measurement (see Appendix XIII). In total the ICC values of all outcome variables ranged from 0.11 to 0.77. More specific the ICC values in the **first** static NMC test (balance) showed an overall fair to good agreement (0.46 – 0.64). The **second** static NMC test (proprioception) represented only a poor to fair agreement with coefficients from 0.11 – 0.42. With respect to the **third** dynamic NMC test left-right the reliability was proven to be poor to fair (0.29 - 0.59). The coefficients in the **fourth** NMC test (front-back) varied tremendously from a poor (0.32) to an excellent agreement (0.77). The coefficients in the cross-diagonal **fifth** NMC test agreed with 0.57 only fair. The agreement of the **sixth** NMC test (donut) was categorized as poor to fair (0.23 - 0.53). The **seventh** dynamic NMC test (circle) gave also a fair agreement with a coefficient of 0.49. All data had significant positive correlations with $p \leq 0.05$, except two outcome variables of two NMC tests: in the second static NMC test (proprioception) the variable “angle tilt” to the front with $p=0.266$ as well as in the sixth NMC test (donut) the variable “overall performance” with $p=0.098$.

Normative reference data

The reference values regarding the “overall performance” of each NMC test are shown in Table 7 and Appendix IX. With respect to both **static** NMC tests, a value of ≥95.0% (balance) respectively ≥92.0% (proprioception) corresponded to good balance skills. A value <91.0% (balance) respectively <85.0% (proprioception) described a poor balance. In consideration of the five **dynamic** NMC tests, a value ≥54.0% (left-right), ≥61.0% (front-back), ≥53.0% (cross-diagonal), ≥68.0% (donut) or ≥86.0% (circle) represented good balance skills, values ≤39.0% (left-right), ≤43.0% (front-back), ≤38.0% (cross-diagonal), ≤57.0% (donut) or ≤71.0% (circle) showed an overall poor balance.

Table 6: Correlation Analysis NMC test variables: intra-class correlation coefficients and confidence interval

Variable in percentage or degrees	Initial test and Retest ICC (95% Confidence Interval (CI))	*p* value
static tests		
balance 1st		
performance (%)	0.64 (0.39 - 0.81)	$p < 0.001$***
front (°)	0.60 (0.31 - 0.78)	$p < 0.001$***
back (°)	0.46 (0.14 - 0.69)	$p = 0.003$**
left (°)	0.52 (0.22 - 0.73)	$p = 0.001$***
right (°)	0.55 (0.26 - 0.75)	$p < 0.001$***
balance, proprioception 2nd		
performance (%)	0.36 (0.03 - 0.62)	$p = 0.017$*
front (°)	0.11 (-0.25 - 0.44)	$p = 0.266$****
back (°)	0.42 (0.10 - 0.66)	$p = 0.005$**
left (°)	0.29 (-0.02 - 0.56)	$p = 0.027$*
right (°)	0.42 (0.11 - 0.66)	$p = 0.004$**
dynamic tests		
left-right 3rd		
performance (%)	0.45 (0.11 - 0.69)	$p = 0.001$***
inside front (%)	0.48 (0.17 - 0.70)	$p = 0.001$***
inside back (%)	0.29 (-0.02 - 0.56)	$p = 0.024$*
front (°)	0.38 (0.07 - 0.63)	$p = 0.010$**
back (°)	0.48 (0.11 - 0.72)	$p < 0.001$***
left (°)	0.48 (0.12 - 0.72)	$p < 0.001$***
right (°)	0.59 (0.23 - 0.79)	$p < 0.001$***
front-back 4th		
performance (%)	0.51 (0.21 - 0.72)	$p = 0.001$***
inside left (%)	0.46 (0.16 - 0.69)	$p = 0.002$**
inside right (%)	0.43 (0.11 - 0.67)	$p = 0.006$**
front (°)	0.63 (0.21 - 0.82)	$p < 0.001$***
back (°)	0.77 (0.12 - 0.92)	$p < 0.001$***
left (°)	0.60 (0.33 - 0.78)	$p < 0.001$***
right (°)	0.32 (-0.02 - 0.60)	$p = 0.032$*
cross-diagonal 5th		
performance (%)	0.57 (0.29 - 0.76)	$p < 0.001$***
donut 6th		
performance (%)	0.23 (-0.12 - 0.53)	$p = 0.098$****
deviation inside (%)	0.39 (0.05 - 0.64)	$p = 0.013$*
deviation outside (%)	0.53 (0.23 - 0.74)	$p = 0.001$***
circle 7th		
performance (%)	0.49 (0.18 - 0.71)	$p = 0.002$**

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$, ****$p > 0.05$

Table 7: Reference data regarding the measurement variable "overall performance" in percentages

NMC Test	100.0 - 76.0% (quantile) **(1) good**	75.0 - 26.0% (quantile) **(2) medium**	25.0 - 00.0% (quantile) **(3) poor**
static tests			
balance 1st	≥ 95.0	94.0 - 91.0	< 91.0
balance, proprioception 2nd	≥ 92.0	91.0 - 85.0	< 85.0
dynamic tests			
left-right 3rd	≥ 54.0	53.0 - 40.0	≤ 39.0
front-back 4th	≥ 61.0	60.0 - 44.0	≤ 43.0
cross-diagonal 5th	≥ 53.0	52.0 - 39.0	≤ 38.0
donut 6th	≥ 68.0	67.0 - 58.0	≤ 57.0
circle 7th	≥ 86.0	85.0 - 72.0	≤ 71.0

4. Discussion

Aims of this study

The main purpose of this practice-based research was to investigate the test-retest reliability of the interactive training software NMC using the Sensbalance MiniBoard in healthy young adults. Secondary aim was the publication of reference values for the "overall performance" in each NMC test.

Summary of results

Descriptive Analysis

Because an intervention was not part of this study, it was assumed that balance skills and therefore the single results of each NMC test will not show wide changes from the initial test to the retest. The study group performed on average better on their first than on their second testing day. Nevertheless, the differences of median values from the initial test to retest were small. With respect to both static NMC tests the participants were able to keep the board better horizontal and steady when visual feedback was given (first NMC test balance). With consideration of the five dynamic NMC tests it was detected that the participants had mostly difficulties to execute the left-right NMC test. However, these outcomes are partly in accordance with the subjective experience of the participants who stated in summary that the first NMC test (balance) was the easiest, and the seventh NMC test (circle) the most difficult one.

Correlational Analysis

The correlation between single values of the individuals was examined to investigate the test-retest reliability. According to Cicchetti´s definition[22] the overall test-retest reliability of this experiment resulted in a poor to excellent agreement with ICC ranging from 0.11 - 0.77.[22] This finding initially does not support the use of the balance tool because it is advised for a physiotherapist to use a tool which has a reliability of at least 0.80[11]. In this study the researcher put the main focus on the results gained in the variable "overall performance". Since the ICC values of this variable showed a poor to good agreement in the two static NMC tests and a poor to fair agreement in the five dynamic, the predication about non-application of the balance tool was confirmed. Anyway, when considering the use of a measurement tool, it is advised not only to look for the degree of the reliability coefficients. It is recommended to keep in mind, amongst others, the type of measurement tool and the context in which the tool will be used.[23] However, an overall positive correlation between all values was achieved. The reliability was highest in the first static NMC test (balance) during which subjects performed also best and reported it as the most easiest to execute. Still, it was figured out that the strength of correlations of measurement one and two varied highly within the NMC tests. Generally, it is assumed that the heterogeneity of a sample influences the ICC. If the between-subjects variability is large, the ICCs are likely to result in a higher range and vice versa.[20] By examining the outcomes of the Shapiro-Wilk tests, in which all data were analysed for their distribution, some variables were calculated as being not normal distributed. As thereby the NMC test results differed amongst the participants, it was possible that this could be a reason for the overall wide range of the ICC in this study.[24-26] Therefore, it might be worth to consider additionally the heterogeneity of the results when looking at the ICC findings. Besides, Batterham and George[27] discovered that a smaller group size are rather characterized by outliers and those data could likely affect the overall outcome of a study.[27] They argued that a sample size of at least 30 subjects is needed to detect a proper precision and even more (n>50) for a typical error.[27] This has to be kept in mind when interpreting the findings in the current study.

Normative reference data

Although there were statistical significant differences in the test-retest reliability analysis, the group size was small, and the participants were healthy physiotherapy students, the researcher stated reference values for physiotherapeutic use. The reason therefore was that so far no reference data for the NMC tests have been published. So, the reference data from this experimental study can be used as a starting foundation. Balance abilities can be compared with the values gained in this group along with the CI and IQR to determine if the performance of a person is within normal parameters. In this study only the findings of the variable “overall performance” from each NMC test was further categorized on a scale describing the balance skills as ‘good’, ‘medium’ or ‘poor’. Clinicians can use those ranging data for their evaluation in the rehabilitation process of patients’ outcomes. Patients, for example with limitation of ankle dorsiflexion and poor proprioception, could get sessions with this interactive training software NMC and judge their performance on the MiniBoard in relation to the normative reference values.[14] The own results, which would be gained over time in the training sessions, could be contrasted with each other. The patient could use this as a direct feedback about own balance abilities and as support in the treatment progression. Also the physiotherapist could get a better insight if the interventions made were helpful and led to balance improvements or less. But nevertheless, the analysed degree of reliability of this balance tool should be kept in mind as well as the fact that testing conditions differ from clinical settings that could lead to other results than gained in this experimental study.

Distortion of test results

The occurrence of measurement errors could influence outcomes of studies. Researchers divided those errors into random and systematic.[20-21,27]

Random errors can be related to the subject, measurement(s), environment or assessor. With respect to the subject, changes from one measurement to the other could have been for instance due to natural variations in physical performance.[14] Normal, biological changes, compromising physical (changes in muscle strength or flexibility) and psychological aspects (mood or nervousness), could have had an impact on overall performance, (different) on the two measurement days. Furthermore, the researcher was not able to ensure a unique starting condition on both testing days: activities done before the experiment by the subject could not be fully controlled but might have affected performance. For example having an early, demanding class before one testing day could easily have led to a tired state and therefore to suboptimal test results in comparison with having a good night’s rest at the other testing day which resulted in better performance due to a better functioning sensorimotor system. Pre-testing conditions could be arranged more precise the next time by ensuring equal starting conditions of the individual.

Errors concerning the measurement(s), in this case the Sensbalance MiniBoard with interactive training software NMC, could have reasoned the weaker correlations. Before the start of one test, the MiniBoard needed to be calibrated. In case of problems with calibration, the results in the first testing phase could have been different to the second.[27] Moreover, it was detected while pilot testing, that there was a certain degree of movement of the cushion placed under the board. The magnetic click on system seemed to be repairable. Therefore, it could not be guaranteed that this affected the data. The researcher tried to keep the cushion as fixed as possible by applying a proper tape around it to reduce its freedom of movement. The cushion was checked regularly and the tape reapplied if necessary. Next to it, it was discovered in the pilot testing that the MiniBoard in general is very sensitive to external movements. When the MiniBoard was placed on the ground but not being touched in any way, it still led to very small movements of the red ball on the screen when someone was walking close to the board. The researcher made sure that enough distance was kept to the subject and material during the experiment.

Moreover, environmental impacts that could have distracted the participant such as surrounding noises, light, temperature or time of the day could have been different on the two measurement days. Since in the second testing week in the whole building were site operations and it was exam period, random people entered unawares the testing room. Thereby, it could be likely that especially those environmental influences manipulated the outcomes of the retest to a certain amount. However, the researcher tried to minimize any possible external influences in both testing weeks by not only securing a quiet surrounding but also by keeping environmental testing conditions (light and testing time of the day) equal for each individual on the initial test and retest.

Other influencing factors, that could have been responsible for random errors, were aspects related to the assessor. The use of the balance assessment tool required a certain level of knowledge and practice. Since the Sensbalance MiniBoard with interactive training software NMC was a novel device for the researcher, the familiarization period was limited. Due to its user-friendly properties, it was however unlikely that any incorrect use during the experiment was made.

The other classification of errors, described as systematic, is considered not to contribute to unreliability.[26] Systematic errors are mainly unavoidable and not influenceable. Those include for example fatigue and learning effect, which could have occurred in this study from the initial test to retest. Since the subject's use of the equipment was short (maximum 30 minutes in each testing phase) and no intervention or practice time after the initial test was given, a learning effect was not expected. As the subjects performed higher in the first testing week, it was clear that no considerable learning effect occurred. The only systematic error that could have been a reason for the study outcome was physical fatigue. Each subject was asked to execute in total seven balance tasks. Because the NMC tests required a certain amount of concentration and effort, fatigue could have appeared. However, the break between each sub-test was adjusted to the subject's need because the recovery potential varied within a person. Since the researcher made sure that the order of the tasks was the same for the participants on both testing days, the onset of fatigue was expected to be the same in the initial test and retest. Still, the incidence of fatigue could have been different in the two phases. In the pilot testing it was detected that the execution of the dynamic tasks would lead earlier to fatigue than the less challenging static NMC tests.

Comparison to studies

A direct comparison to other studies cannot be made because there is no literature or any kind of research done yet about the NMC test equipment from Sensamove®. However, it was referred to studies that performed similar tests with comparable tools. Wobble boards are supposed to act on strengthening and stretching of muscles as well as on the aerobic and balance performance of the user.[19,28] Researchers created instrumented combinations with those boards and tested them to check their implementation into clinical settings. Several studies demonstrated that the WBB, a comparable functional device to the Sensbalance MiniBoard, can be used to train a person's balance skills.[10,12,28-31] Continuative going studies indicated that it can be also used for assessment.[10,12,14,30,32]

The study by Park and Lee[10] tested the reliability of the balance assessment software, Balancia v1.0, using it with the WBB and compared it with a standard laboratory grade force platform.[10] Both devices estimated similar values for measuring balance in healthy adults (aged 18-40 years). By comparing the centre of pressure (COP) path length and velocity from the software connected to the WBB, the researchers gained excellent intra-rater reliability (ICC: 0.70-0.92) and inter-rater reliability (ICC: 0.79-0.89), which was investigated by two assessors. The WBB-based system demonstrated a lower-priced and more comprehensible tool than the laboratory grade force platform. As an alternative it decreased the difference between laboratory experiments and clinical settings.[10] Compared to the present study, the participants in the study from Park and Lee were only tested with four exercises. They stood on both legs, once with eyes open and once closed, as well as on one leg, again one time the eyes were open and the other time closed. Besides, the exercises' duration was only 30 and ten seconds, respectively.

Chang et al.[12] tested the reliability of a Wii Fit balance board with the software DarwiinRemote by comparing it with the Smart Balance Master System (SBM), an expensive, immobile and complex device, on healthy young adults (mean age 22.17 years) and elderly (mean age 67.32 years).[12] According to their study, the modified Wii Fit balance board is a reliable balance assessment tool, but due to a low reliability (ICC= 0.19-0.28) when testing young adults but higher (0.93-0.99) when testing elderly people, so far it is only recommended as an alternative tool to assess balance in elderly. The researchers assumed that the younger population was more familiar with those balance boards and kinds of software. Therefore, the impulse to manipulate the equipment while being tested was likely to occur, similar with movement controllers of video games that are often used by this generation in daily life.[12] This explanation could also be related to this study outcome in which younger students were tested two times.

Wikstrom[30] investigated the reliability of Nintendo Wii Fit Balance scores.[30] All 12 activity scores resulted in an overall low degree of intrasession and intersession reliability: the ICCs ranged from 0.39-0.80. The researcher did not recommend using the Wii Fit balance scores as an objective measurement tool; further research was requested. However, the researcher stated that the novelty of the device to the participants were reason for overall outcomes. An increase in the number of trials before testing might improve findings.[30] Also in the present study the familiarization period with the tool might have been too short.

The study by Williams and Bentman[14] discovered that the SMART wobble board is a quick and reliable way to assess balance performance in a healthy population.[14] The researchers only tested them on the within-day reliability which was a shorter time interval than this experiment. They tested this equipment also on young physiotherapy students, but let them wear shoes. In this study the subjects performed the balance tasks barefoot. Indeed, for future research it could be considered to let participants wear shoes of more or less the same appropriate type, which might also represent the reality in clinical practice. For this study it was assumed that wearing shoes could have made testing conditions inequitable if the person wears proper sport shoes but the other time only regular outdoor shoes or even boots when considering the season. In addition, it could have been even a risk factor, if the type of shoes was not good to perform the exercises with. Therefore, the intent was an unaltered reflection of the balance abilities, rather achievable when being barefoot.

However, to summarize the comparison with other studies, researchers argued that their diverse tested tools and software could be used as an alternative for the training as well as assessment of balance skills, although the quality criteria did not deliver preferred values. Reason for that are amongst others the beneficial effects of the tools. This assumption could be also valid for this conducted study because the tools are similar and the kind of research done about it can be related to each other.

Limitations of this study

The small group size of the current study indeed restricts the generalizability but was, however, sufficient for exploratory research. The observed findings can be initially assigned to young, healthy, physiotherapy students.[25] Furthermore, the physiotherapy students could have had already experiences with this kind of balance tool. Therefore, the outcomes of this study might show results higher-than-average. Additionally, the physical performance of each individual could also have varied from one testing to the other according to a different speed used to move on the board. The subjects were told to perform as well as possible and no time limits for moving the board were given. To ensure a constant speed of moving the board in each NMC task by the individual, which would be then more equal on both testing days, the next time a metronome could be used as it is suggested in the study of Broadstone et al.[32]. Moreover, each individual had the chance to get familiar with the equipment, but only for about five minutes. This short practice trial time could explain the overall low reliability outcome. Increasing the number of trials before the real testing took place could have created a higher self-confidence and comfort of the participant, eliminate possible learning effects and thereby provide more equal starting conditions for the individual in both testing phases. Besides, in consideration of the test-retest reliability analysis, the calculated ICCs do not state the magnitude of disagreement between the two measurement phases within an individual.

Strengths of this study

The main strength was that this experimental study provides first data about the Sensbalance MiniBoard with interactive training software NMC. Efforts were made by the researcher to keep the testing conditions similar on both testing days: not only by sticking to the protocols but also by keeping the built up of the materials used, the timing and environment similar. Additionally, the two weeks’ time interval was considered to be short enough to keep several possible changes, like an improved level of fitness, to a minimum, and long enough to prevent recall bias. Besides, it was checked that nothing happened within the break that could have influenced the balance skills in the second testing week, such as even small injuries. That was done by asking the patient this relevant information on the second testing day in order to minimize avoidable variations between initial test and retest. Furthermore, the participant was told not to practice in between the two sessions with such a balance tool in order to minimize possible learning effects. Besides, the amount (seven NMC tests) and type of exercises (static and dynamic) as well as the general and individual settings were detected to be chosen appropriate for this group. The demands were not too difficult but still challenging and variable.

Clinical Relevance

The Sensbalance MiniBoard with interactive training software NMC could be applied in a physiotherapy department as a clinical balance tool because several features were requested in the NMC tasks in diverse ways and the use confirmed lots of benefits.

In order to cope with tasks in daily life, we require a proper static and dynamic balance. It was assumed by the researcher that the dynamic balance tasks symbolize a greater challenge. That was confirmed with the results in this study. The participants performed in the dynamic left-right NMC test worst and subjectively reported the dynamic NMC test circle as the most difficult to execute. Adequate balance depends highly on the interaction of complex sensorimotor systems. Therefore, humans are highly dependent on information from the eyes (vision), skin, muscles, joints (proprioception) and vestibular organs (vestibular system), which give sensory inputs to the brain where the integration and information processing takes place, and receive motor outputs, which is sent there by the brain. This allows the human to interact appropriate to situations. The balance skills decrease as soon as the system does not work well. The device focuses on improving the sense of proprioception and neuromuscular control, and several issues involved in the complex sensorimotor system were addressed more specific which could lead to an overall better health and well-being. The sensory and motor systems, active (muscles, tendons) and passive structures (bones, ligaments) that were mainly required for the accomplishment of the exercises, as well as the capacity of proprioception, flexibility and strength (especially of the core and lower extremities) were stimulated. In the Journal of Strength and Conditioning Research the author, Anderson[33], stated that exercises on wobble boards activate muscles fibres in specific areas of the body to a greater amount compared to exercises that do not use these boards.[33] Those areas are the lower back (42-70%), lower abdominals (22-34%), quadriceps (61-84%), hamstrings (33-70%) and calves (17-51%).[33] Those facts were proven with the MiniBoard and NMC training software. Next to it, the balance tool is inexpensive, user friendly, economical and portable as well as adjustable to a wide range of individuals and their (impaired) characteristics, which were, in addition, advertised by Sensamove®. The latter can be achieved by giving the possibility to change the level of exercise difficulty.[15,17] The protocols made for this experiment just illustrated examples of a use of this software: the choice of cushion, duration of exercises and general and individual settings of the NMC tests were chosen on the opinion of the researcher and after pilot testing.

Future Research and perspectives

The repeated measurement demonstrated partial wide differences in ICCs and the overall poor-excellent reliability questions by that the tool's capacity for delivering meaningful data. The balance tool may lead to false statements and incorrect interpretations of the physiotherapist when testing a patient on balance skills. Therefore, the testing protocols need to be rechecked and the equipment from Sensamove® might need reassessments in order to draw a clear conclusion about its application in physiotherapy. However, the interpretation of the present overall study outcome should be taken with caution.

As recommendations for future research more participants and more strict protocols are needed to detect whether changes in balance skills are true or affected by measurement errors. This study was limited to healthy physiotherapy students. Future research could also test and compare different population groups.

5. Conclusion

The overall study outcome showed that the NMC test results provided a poor to excellent test-retest reliability. The researcher stated reference data for clinicians that could be used for the evaluation of balance skills. The findings suggest using the Sensbalance MiniBoard and interactive training software NMC as an objective assessment tool with cautious and/or in combination with other tools. However, users might benefit from the application of this balance tool in the training process by not only improving their balance skills, but also amongst others to improve neuromuscular control, proprioception, and motivation. The tool focused on several balance issues that are needed to interact with demands in daily life. Participants had to move on the MiniBoard with respect to the demands of the NMC tests that provided a diverse, challenging and enjoyable situation. However, future research is recommended to prove appropriate quality criteria of this novel tool that is necessary for its reliable implementation into clinical settings.

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Appendices

I. Invitation Letter

Invitation Letter

Graduation Research Project 2014-2015

Sensbalance MiniBoard and Normal values Interactive Trainings software NMC

Dear students,

As you probably got to know already, the first group of the 4th year physiotherapy students at Fontys are working now on their scientific research projects. I am part of this group and would like to invite also you now to be part, but of my experimental study.

It is about the assessment of a person's balance skills standing on a wobble board and executing seven different exercises. The aim is to find out if the overall assessment tool used for that is reliable and therefore recommendable in clinical settings.

The creator of the equipment we are going to use, called Sensamove®, advertise that their mission is to make a balance training more enjoyable and understandable. The tool they developed- the Sensbalance MiniBoard with interactive trainings software NMC tests- aims to restore and/or improve a person's balance, coordination, hull stability, proprioception and neuromuscular control. Being part of physiotherapy, rehabilitation and fitness or also being available at one's home or workplace makes this tool so innovative and interactive.
With taking part in my experiment you help me to create normal values for the neuromuscular control (NMC) tests using this Sensbalance MiniBoard and interactive training software.

An interesting factor to mention about my project is the fact that I am the first one testing the NMC software on its reliability. So far there hasn't been done any research also due to the fact that the equipment is made by a young, dynamic innovative company in Utrecht in 2011.

I think it will be also for you a nice opportunity to get already some insights in a graduation research project because soon you will be in my position having a similar situation.
There are no serious risks involved, possible cramps in the lower extremities could occur due to uncommon prolonged muscle activities. Otherwise the only thing you need to do is coming two times to my experiment and trying out your balance skills on this widely applicable training and therapy tool. You will be tested standing with both feet on the board.

Caught your interest?

Then please go ahead, read the attached information letter carefully and in case contact me about any further questions. Additionally to that, feel free to also read through the website and watch the video available online to gain an idea about the tool I am talking about. Go to: http://www.sensamove.com/en/producten/sensbalance-miniboard/.

Please let me know before **13th October** if you would like to be part of the experiment. And in case you have any wishes regarding the time of testing, please mention it and I will try to schedule you on your preferred day and time.

I hope to hear from you,

By then best greetings,

Anneke Klostermann

II. Information Letter

Information Letter
Graduation Research Project 2014-2015

Sensbalance MiniBoard and Normal values Interactive Trainings software NMC

Introduction

First of all, thank you very much for your further interest about the participation in my study!!
In order to find out if you are a suitable subject for this project, I am going to inform you more detailed about my goal and the requirements you need to bring. Please take a few minutes to read this letter carefully. If you have any additional questions after, do not hesitate to contact and ask me.

What is the purpose of this study?

Balance skills are essential in daily life for everyone. Many activities require a proper static or dynamic postural control. Balance impairments have a significant impact on a person's daily life and are frequent causes of people seeking for a physical therapeutic advice. Any balance problem needs a systematic clinical assessment for developing an effective treatment. In physiotherapy, materials such as a balance board are therefore frequently used to assess balance impairments and later on to train balance skills.

The Sensbalance MiniBoard combines interactive training software (Neuromuscular Control tests - NMC: static balance & test figures) with the characteristics of a balance board. Those boards are often used in physiotherapy as being part of an assessment or treatment. Sensamove® created a balance board with software that can be used on a laptop.
Since there is not yet done a study about the use of the NMC software, the purpose of this research is to find out if the Sensbalance MiniBoard with the interactive training software NMC can be seen as a reliable measurement tool.

What is going to happen in the experiment?

Prior to testing, we will discuss again what is going to happen in the experiment, you need to fill out a short questionnaire and to sign an informed consent.
The project itself consists of two parts, meaning you will be tested twice- on two different days but on performing exactly the same tests. We will first do a trial before the real experiment takes place.
The MiniBoard represents a functional related equipment where the balance ability is tested from you standing on the board and trying to execute seven different exercises while you have to maintain balance as best as possible. Thereby your postural control is tested while doing different small movements on a movable surface.

Who can participate in it?

- physiotherapy students, having completed the eighteenth years
- being able to communicate in English
- not diagnosed with any kind of balance disorder (like benign paroxysmal positional vertigo (BPPV) or Meniere's disease)
- currently not diagnosed with a major medical condition (such as neurological disorder or infectious disease)
- not suffering from any pathological, abnormal health condition which could influence the balance ability (such as ear infections, blood pressure changes)
- not having regular symptoms like dizziness, blurred vision, light-headedness, faintness, disorientation, nausea/ vomiting, and/ or having troubles with sleeping or concentration
- being free from any (severe) injury of the back, hips, knees, ankles and/or feet six months prior to participation
- being free from any medication intake which could have an effect on balance
- vision being impaired, but glasses and contact lenses are accepted
- students performing any physical activity >5 times per week on a competitive level, which could give a competitive edge opposite to other participants

What are advantages and/ or disadvantages of participating?

This study does not bring any disadvantages for you. The only small risk which could happen is cramps in the lower extremities due to slight strenuous muscle activity.

The testing will be executed on two different days in October, each time about 30 minutes in the Fontys building TF in one of the practical rooms. You will be tested individually with my personal guidance.
With your participation you will get already an insight in how to conduct an experimental study which you are perhaps going to do soon as well.
So challenge and test yourself on your balance skills!

When and where takes the experiment place?

You will receive your exact time after you let me know that you will participate.

Building: Fontys University of Applied Sciences, Eindhoven TF

Room: Practical room (depends on your testing days)

When: 1st Trial – 15/10/2014 – 17/10/2014 between 09.00-18.00

and

2nd Trial – 29/10/2014 – 31/10/2014 between 09.00-18.00

How long: Two times approx. 30 minutes each

Is everything clear for you? Feel free to contact me about any concern and/ or the supervisor of the project via the contact details written down below.

Take your time to think about if you would like to volunteer. I am looking forward to your positive answer! You can let me know your participation via E-Mail, remember before **13th October**.

I hope to see you then in my testing.

Best greetings,

Anneke Klostermann

Researcher: Anneke Klostermann a.klostermann@student.fontys.nl

Supervisor: Leteke Vos-Slaats l.vosslaats@fontys.nl

III. Informed Consent

Informed Consent
Graduation Research Project 2014-2015

Sensbalance Mini Board and Normal Values Interactive Training Software NMC

Participant

I have read the information letter for the research done by Anneke Klostermann. I am well enough informed about the purpose of the study and the procedure of the experiment. I am aware of the fact that the participation is voluntary and I am allowed to withdraw it at any time and that the testing is not linked to any potential risk. I agree that photos will be taken during the testing. I was told that any data exchanged stay between the researcher, supervisor and organization only. Thereby I give my permission of using my data, saved anonymous, up to 10 years after the end of the project.

After due consideration, I decided to take part in the experiment.

Hereby I, ______________________________________ declare that I am fully informed about the experimental study and agree to the consent written above.

Date: ______________________________

Signature: ______________________________

Tester

Hereby I, ______________________________________ declare that I informed the participant well enough about all necessary information. In case that any data is getting public, I will get in contact with the participant as soon as possible. Additionally, if there will be any kind of changes of the research project, the participant will be informed.

Date: ______________________________

Signature: ______________________________

IV. NMC Protocol

NMC Protocol
Graduation Research Project 2014-2015

Sensbalance MiniBoard and Normal values Interactive Trainings software NMC

Preparation by the assessor

All the needed equipment is built up in the testing room.

1. The laptop is turned on and the Sensbalance software version 2.3 from Sensamove® is opened
2. The Sensbalance MiniBoard is connected via the USB cable to the laptop and the board with the cushion (15°) put in place on the floor
3. Click on → exercises → NMC tests
4. The settings for each sub-tests is set (see description below):

General Settings and conditions

For all the sub-tests the following settings are valid, according to pilot testing and available literature:

Maximum tilt angle: 15°
Duration: 60 seconds

The following conditions are applied to all the seven exercises (based on pilot testing and literature): the participant stands barefoot with knees slightly bent, avoiding hyperextension, on the board and both hands are allowed to be moved freely. The feet remain in one original position throughout all exercises: tape markers are placed after the trial testing on the board. The MiniBoard needs to be calibrated every time before the start of an exercise.

General individual instruction to the subject

The assessor introduces the experiment to the participant as the following: "We are going to test your balance skills by seven different exercises while you are standing barefoot on this board. Each exercise demands something different. Try to perform them as best as possible, it is not about celerity so take your time and try to perform as best as you can. One test lasts 60 seconds, so do not stop before that, there will appear a sound when the one minute finished. You will get a break after each test. We are going through each of the exercises once, you have time to try them out and find your once-for-all feet position on the board. I will put tape on the board so that you recognize your position. As soon as you are ready and feel familiar with the board, we can start with the real testing."

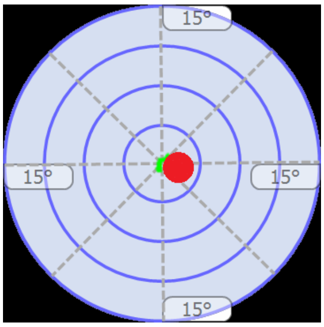
Individual settings and instructions

Static Balance Tests:

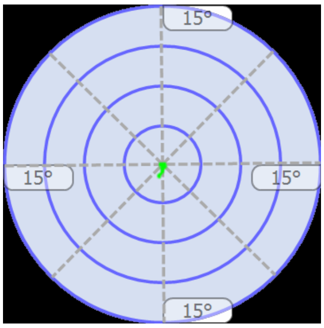
· 1. With visual feedback:

Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds

Instruction:
The person is positioned on the board as mentioned before and instructed to remain as stable and still as possible. The red ball visible on the screen needs to stay as centred and still as possible.



· 2. Without visual feedback (proprioception):



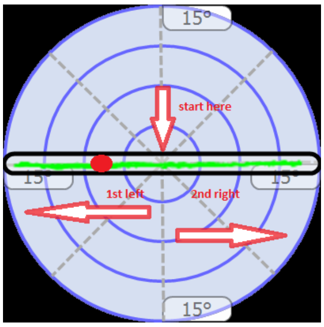
Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds

Instruction:
The subject is asked to execute the same as in the static test 1. But now the red cursor on the screen is not seen.

Dynamic Balance Tests:

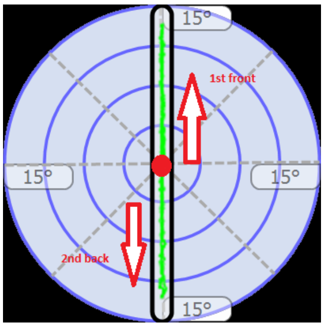
· 3. Left-right horizontal:

Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds
Shape size: 30.00°
Shape width: 2.00°



Instruction:
The client moves continuously from the centre to the left, back to the centre and then to the right and back to the centre in a horizontal plane. This order is executed till the 60 seconds are over. The subject is asked to perform it as best as possible with a proper pace constant all time. The ball needs to stay inside the figure, if the red cursor is brought over the line, the line changes its colour to red, representing an error.

· 4. Front-back vertical:

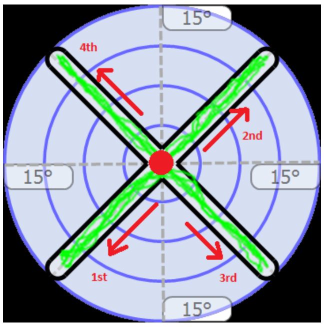


Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds
Shape size: 30.00°
Shape width: 2.00°

Instruction:
The subject moves continuously from the centre to the front, back to the centre and then to the rear and back to the centre in a vertical plane. The client should perform this order as best as possible in a proper pace for 60 seconds. The ball needs to stay inside the figure, if the red cursor is brought over the line, the line changes its colour to red, representing an error.

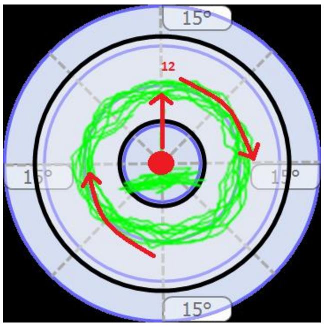
· 5. Cross-diagonal:

Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds
Shape size: 30.00°
Shape width: 2.00°



Instruction:
The subject needs to move on the board so that the red cursor is brought from the left front, to right rear, back to the middle, then from right front to left rear and back to the middle. This order is repeated till the time is over. Again the client should perform this as best as possible in a proper pace for 60 seconds. The ball needs to stay inside the figure, if the red cursor is brought over the line, the line changes its colour to red, representing an error.

· 6. Donut:

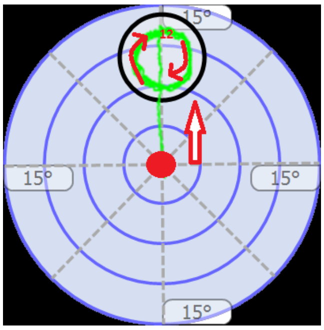


Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds
Shape width: 8.00°
Radius: 8.00°

Instruction:
The client needs to move clockwise starting from the centre and bringing the ball up to an imaginary 12 o'clock inside the circle. The red cursor is moved inside the donut field clockwise. Again, if the red cursor is brought over the line, the line changes its colour to red, representing an error.

· 7. Circle:

Settings:
Maximum tilt angle: 15.00°
Duration: 60 seconds
Shape width: 12.00°
Position from centre: 5.00°
Radial position: 0.00°



Instruction:
The subject needs to move inside the circle starting from the centre and then going to 12 o' clock. The red cursor is moved clockwise, it needs to remain inside the small circle. If the red cursor is brought over the line, the line changes its colour to red, representing an error.

Client enters the room. **Trial testing of MiniBoard**

1. The assessor introduces himself to the participant
2. The assessor and participant clarify last unanswered questions and fill out the *questionnaire*
3. The assessor explains all relevant information about the experiment and what is expected
4. The participant signs the *informed consent*
5. Both go to the testing place
6. The assessor clicks on → clients → add client; the assessor puts all relevant data collected before from the *pre-testing data collection table* (full name subject, subject number, date of birth, gender, length and weight) inside the new file
7. The participant takes of shoes and socks
8. The assessor calibrates the Sensbalance MiniBoard
9. The subject places both feet on the board and tries to find a position where he/ she feels most comfortable/ stable. He/ she stands still for a few seconds but also moves in certain directions
11. The subject steps off
12. The assessor clicks on → exercises → NMC tests and opens the first exercise *(Static Balance)* and explains the goal of it
13. The assessor clicks on → calibrate
14. The participant steps on the board and exercises
15. The participant steps off and takes a short break
16. The assessor opens the second exercise *(Static Balance, Proprioception)* and explains the goal of it
17. The assessor clicks on → calibrate
18. The participant steps on the board and exercises
19. The participant steps off and takes a short break
20. The assessor opens the third exercise *(Dynamic Balance, left-right)* and explains the goal of it
21. The assessor clicks on → calibrate
22. The participant steps on the board and exercises
23. The participant steps off and takes a short break
24. The assessor opens the fourth exercise *(Dynamic Balance, front-back)* and explains the goal of it
25. The assessor clicks on → calibrate
26. The participant steps on the board and exercises
27. The participant steps off and takes a short break

28. The assessor opens the fifth exercise *(Dynamic Balance, cross-diagonal)* and explains the goal of it
29. The assessor clicks on → calibrate
30. The participant steps on the board and exercises
31. The participant steps off and takes a short break
32. The assessor opens the sixth exercise *(Dynamic Balance, donut)* and explains the goal of it
33. The assessor clicks on → calibrate
34. The participant steps on the board and exercises
36. The participant steps off and takes a short break
37. The assessor opens the seventh exercise *(Dynamic Balance, circle)* and explains the goal of it
38. The assessor clicks on → calibrate
39. The participant steps on the board and exercises
40. The assessor marks with the tape the ideal feet position (stripe is applied on the board behind both heels, in front of and on the medial side of the big toes) and takes additionally a photo of it as demonstration for the next testing day

The client steps off and takes a rest for at least three minutes, if preferred while sitting on the chair.

Real testing

The order of the exercise is the same for each individual on both testing days but randomised between all the participants. Use is made of a sequence random generator (www.random.org).

1. The assessor opens the first exercise
2. The assessor clicks on → calibrate
3. The participant steps on the board with respect to the markers and finishes the exercise
4. The participant steps off and takes a break
5. The assessor saves the result on the laptop and under the software and opens the second exercise
6. The assessor clicks on → calibrate
7. The participant steps on the board with respect to the markers and finishes the exercise
8. The participant steps off and takes a break
9. The assessor saves the result on the laptop and under the software and opens the third exercise
10. The assessor clicks on → calibrate
11. The participant steps on the board with respect to the markers and finishes the exercise
12. The participant steps off and takes a break
13. The assessor saves the result on the laptop and under the software and opens the fourth exercise
14. The assessor clicks on → calibrate
15. The participant steps on the board with respect to the markers and finishes the exercise
16. The participant steps off and takes a break
17. The assessor saves the result on the laptop and under the software and opens the fifth exercise
18. The assessor clicks on → calibrate
19. The participant steps on the board with respect to the markers and finishes the exercise
20. The participant steps off and takes a break
21. The assessor saves the result on the laptop and under the software and opens the sixth exercise
22. The assessor clicks on → calibrate
23. The participant steps on the board with respect to the markers and finishes the exercise
24. The participant steps off and takes a break
25. The assessor saves the result on the laptop and under the software and opens the seventh exercise
26. The assessor clicks on → calibrate
27. The participant steps on the board with respect to the markers and finishes the exercise
28. The participant steps off and takes a rest for at least three minutes, if preferred while sitting on the chair

The client puts on socks and shoes. In case it was the first testing day, the meeting for the re-test is discussed. The participant leaves the room. The assessor prepares in case for the next client.

V. Random Sequence Generator

Random Sequence Generator

Subject (S) Number	Sequence
1	2 4 5 3 6 1 7
2	3 5 1 6 7 4 2
3	2 7 3 6 1 4 5
4	5 7 6 2 3 1 4
5	1 5 3 7 6 2 4
6	5 7 2 3 1 4 6
7	1 5 7 4 2 6 3
8	7 5 3 4 6 1 2
9	7 5 6 3 2 4 1
10	5 1 6 2 4 7 3
11	7 1 4 3 5 6 2
12	5 2 6 7 1 3 4
13	2 6 5 7 1 3 4
14	4 3 2 7 1 6 5
15	7 1 3 2 4 6 5
16	3 5 2 7 4 6 1
17	3 2 5 7 1 4 6
18	7 2 6 3 4 5 1
19	6 7 5 4 3 2 1
20	3 2 1 7 4 5 6
21	3 7 6 5 2 1 4
22	5 7 6 2 3 4 1
23	5 1 3 7 4 6 2
24	2 6 1 3 5 7 4
25	1 2 6 7 4 3 5
26	2 7 4 1 5 6 3
27	4 2 6 1 7 5 3
28	3 5 4 1 2 6 7
29	5 7 3 1 2 4 6
30	3 7 6 2 4 5 1
31	5 3 7 6 4 2 1
32	5 6 2 7 4 1 3
33	4 7 1 2 5 6 3

VI. Questionnaire

Questionnaire
Graduation Research Project 2014-2015

Sensbalance Mini Board and Normal Values Interactive Training Software NMC

To make sure that you are a suitable candidate and have all necessarily information, I kindly ask you to fill out this questionnaire. Be honest and exact because it has an important impact on the outcome of testing.

Full name: ______________________
E-Mail: ______________________
Date of Birth: ______________________
Gender: ______________________
Height in cm: ______________________ (we are going to test this together)
Weight in kg: ______________________ (see above)
Shoe size: ______________________

Are you diagnosed with any kind of balance disorder? (Such as Meniere's disease)
Yes / No
If, which one: ______________________

Are you currently diagnosed with a major medical condition? (Like neurological disorder of infectious disease)
Yes / No
If, which one: ______________________

Do you suffer from any pathological, abnormal health condition? (Such as ear infections, blood pressure changes)
Yes / No
If, which one: ______________________

Do you suffer regularly from any of the following or similar symptoms? (Dizziness, blurred vision, light-headedness, faintness, confusion/disorientation, nausea/vomiting, and/or having troubles with concentration)
Yes / No
If, which one: ______________________

Do you take any kind of medications over a longer period of time?
Yes / No
If, which one: ______________________

Did you injure your back, hips, knees, ankles and/or feet severely six month ago?
Yes / No
If, what? ______________________

Do you do any kind of sport on a quite regular basis?
Yes / No
If, which and how often per week? ______________________

Do you have any aids? (Such as glasses, footwear or hearing aids)
Yes / No
If, which one: ______________________

Hereby I declare that I have answered all the above written questions veritable. I know that wrong answers can affect the outcome of the study.

Name: ______________________

Date and signature: ______________________

VII. Data Collection Table

Data Collection

Graduation research project 2014-2015

Sensbalance Mini Board and Normal Values Interactive Training Software NMC

Full Name Subject:	
Subject Number:	
Date of Birth:	
Gender:	
Shoe size in cm:	
Length in cm:	
Weight in kg:	
Date 1st Testing:	
Date 2nd Testing:	
Individual results saved under:	
Sequence of tasks:	
Subjective experience:	Most easy task: (1st testing phase); (2nd testing phase) Most difficult task: (1st testing phase); (2nd testing phase)

VIII. PDF Outcome

NMC Test

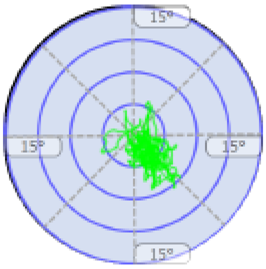
sensamove

Single result: Balance Test, Proprioception (Tilt View)

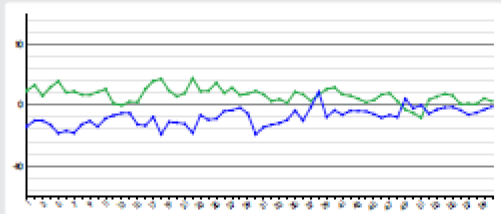
Information

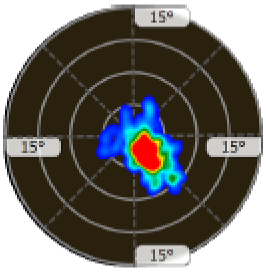
Client Name	Age	Gender	Length	Weight
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Report ID	Date	Time
TST000052	15 October 2014	09:44



Graph





Result (Average per second)

second	Left - Right	Front - Back
1	2.38°	-3.52°
2	3.25°	-2.54°
3	1.50°	-2.56°
4	2.91°	-3.35°
5	3.69°	-4.65°
6	2.00°	-4.25°
7	2.21°	-4.58°
8	1.67°	-3.18°
9	1.66°	-2.60°
10	2.10°	-3.52°
11	2.61°	-2.19°
12	0.27°	-1.73°
13	-0.05°	-1.50°
14	0.55°	-1.30°
15	0.47°	-3.20°
16	2.62°	-3.37°
17	3.93°	-1.96°
18	4.28°	-4.80°
19	2.34°	-2.78°
20	1.42°	-2.89°
21	1.94°	-3.10°
22	4.37°	-4.60°
23	2.25°	-1.67°
24	2.32°	-2.44°
25	3.62°	-2.26°
26	1.97°	-1.01°
27	2.84°	-0.87°
28	1.62°	-0.43°
29	1.85°	-1.39°
30	2.28°	-4.83°
31	1.73°	-3.63°
32	0.64°	-3.24°
33	0.94°	-2.97°
34	0.35°	-2.45°
35	2.15°	-0.93°
36	1.76°	-2.54°
37	0.66°	-0.36°
38	1.70°	2.15°
39	2.60°	-1.99°
40	2.67°	-0.87°

Result (Average per second)

second	Left - Right	Front - Back
41	1.73°	-1.60°
42	1.51°	-0.95°
43	1.04°	-0.99°
44	0.46°	-1.04°
45	0.79°	-1.50°
46	1.72°	-2.03°
47	1.93°	-1.67°
48	0.63°	-1.99°
49	-0.75°	1.01°
50	-1.31°	-0.52°
51	-2.06°	-0.05°
52	0.85°	-1.41°
53	1.39°	-0.75°
54	1.80°	-0.39°
55	1.55°	-0.35°
56	0.17°	-0.84°
57	0.29°	-1.59°
58	0.15°	-1.38°
59	1.06°	-0.77°
60	0.62°	-0.38°

Settings

Scores:
- Performance: 80
- Front, avg. deviation: 1.17
- Back, avg. deviation: -2.80
- Left, avg. deviation: -0.87
- Right, avg. deviation: 1.88

Settings:
- Duration: 60 seconds
- Cursor visible: No
- Path visible: No
- Device: miniBoard
- Maximum tilting: 15.00°

www.sensamove.com

IX. Normative Reference Data

Table: Static Balance Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	Balance_Perf1	87,00	90,00	90,00	94,00	94,00	95,00
	Balance_Perf2	85,00	90,50	90,84	93,50	93,84	95,00

Table: Static Balance, Proprioception Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	Proprioception_Perf1	76,00	83,00	83,00	90,00	90,00	96,00
	Proprioception_Perf2	77,00	85,00	85,00	92,00	92,00	93,00

Table: Dynamic Left-Right Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	LeftRight_Perf1	28,00	41,50	41,84	54,00	54,00	70,00
	LeftRight_Perf2	23,00	36,50	36,84	51,50	52,52	64,00

Table: Dynamic Front-Back Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	FrontBack_Perf1d	33,00	44,50	44,84	58,00	58,68	81,00
	FrontBack_Perf2d	27,00	41,50	41,84	61,00	61,00	64,00

Table: Dynamic Cross-Diagonal Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	CrossD_Perf1e	29,00	39,50	39,84	52,00	52,00	61,00
	CrossD_Perf2e	20,00	36,50	36,84	51,00	51,00	61,00

Table: Dynamic Donut Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	Donut_Perf1f	45,00	56,00	56,00	68,00	68,00	82,00
	Donut_Perf2f	49,00	58,00	58,00	66,00	66,68	81,00

Table: Dynamic Circle Overall Performance

		Perzentile					
		0	25	26	75	76	100
Gewichteter Durchschnitt (Definition 1)	Circle_Perf1g	58,00	73,00	73,00	85,00	85,00	95,00
	Circle_Perf2g	61,00	68,00	68,68	85,00	85,00	92,00

X. Confidentiality Statement

Name: Anneke Klostermann **Student No°:** 2186485

Title: Test-Retest Reliability Of The Interactive Training Software Neuromuscular Control Tests Using The Sensbalance MiniBoard In Healthy Young Adults

Content (description):

Introduction

Assessment and training of balance skills is a domain in physiotherapy and physiotherapists have a great supply of tools for that, like posturography. Investigators, however, revealed disadvantages like being expensive or inaccurate. The Sensbalance MiniBoard with interactive training software Neuromuscular Control (NMC) tests was introduced in this study as an alternative. It consisted of a wobble board, connected with a laptop on which the software was installed. Sensors integrated in the board registered movements made on it. The tool tested static and dynamic balance. However, it has not yet been examined on its quality criteria.

Aim

Aims were the evaluation of the test-retest reliability of the Sensbalance MiniBoard with the interactive training software NMC tests and the capture of reference values.

Method

In this experimental study, conducted in October 2014, participants performed two static and five dynamic balance exercises on the MiniBoard and repeated those two weeks later. MiniBoard movements corresponded with a red ball that left green trajectories on the screen. The variables angle tilt, staying and deviating with the ball from given figures shown on the monitor and the overall performance were recorded. Results from both testing phases were compared, intraclass correlation coefficients calculated and reference values generated.

Results

Thirty three students (16 females; 17 males) participated. On average the subjects scored better on the initial test. Intraclass correlation coefficients for each outcome variable ranged from 0.11 to 0.77. The reference values for the overall performance in percentage in each NMC test were categorized on a scale representing a good, medium or poor balance.

Conclusion

The test-retest analysis within this study showed that the balance tool did not give stable measurements. The researcher recommends using the tool only in combination with others, but benefits, such as being user-friendly and challenging, convince its application in therapy.

1. By signing this Statement, the Fontys Paramedic University of Applied Sciences in Eindhoven commits itself to keep any information concerning provided data and results obtained on the basis of research of which is taken cognizance as part of the above practical research project and of which it is known or can be reasonably understood that said information is to be considered secret or confidential, in the strictest confidence.

2. This confidentiality requirement also applies to the employees of the Fontys Paramedic University of Applied Sciences, as well as to others who by virtue of their function have access to or have taken cognizance of the aforesaid information in any way.

3. The above notwithstanding, the student will be able to perform the practical research project in accordance with the statutory rules and regulations.

Student:		**Supervisor:**	
Name:	____________________________	Name:	____________________________
	____________________________ (signature) Date:__/__/_____		____________________________ (signature) Date:__/__/_____
Coordinator: for receipt		Name:	____________________________
			____________________________ (signature) Date:__/__/_____

XI. Conveyance of Rights

AGREEMENT

Pertaining to the conveyance of rights and the obligation to
convey/return data, software and other means

The undersigned:
1. Ms Anneke Klostermann, Runder Garten 4a, 49356 Diepholz, Germany,
hereinafter to be called "**Student**"
and
2. Fontys Institute trading under the name Fontys University of Applied Sciences, Rachelsmolen 1, 5612 MA Eindhoven,
hereinafter to be called "**Fontys**".

CONSIDERATION

A. Student is studying at the Fontys Paramedic University of Applied Sciences in Eindhoven and is performing or will perform (various) activities as part of his/her studies, whether or not together with third parties and/or commissioned by third parties, as part of research supervised by the lectureship of Fontys Paramedic University of Applied Sciences. The aforesaid activities will hereinafter be called "**Lectureship Study Activities**". At the time of the signing of this Statement, the Lectureship of Fontys Paramedic University of Applied Sciences supervises in any case the studies listed in Appendix 1, but this list is not an exhaustive one and may change in the future.

B. It is of essential importance to Fontys Paramedic University of Applied Sciences that (the results of) the Lectureship Study Activities can be further developed and applied without any restriction by Fontys Paramedic University of Applied Sciences and/or used for the education of other students. Fontys wishes in any event – but not exclusively – (i) to be able to share with and/or convey to third parties (the results of) the Lectureship Study Activities, (ii) to publish these under its own name, where the Student may be named as co-author providing that this is reasonable under the circumstances, (iii) to be able to use these as a basis for new research projects.

C. In case intellectual ownership rights and/or related claims on the part of Student will be/are attached to (the results of) the Lectureship Study Activities, parties wish – taking into account that which was mentioned under (B) – Fontys Paramedic University of Applied Sciences to be the only claimant with regard to said rights and claims. The Student therefore wishes to convey all his/her current and future intellectual property rights as well as related claims concerning (results of) the Lectureship Study Activities to Fontys, subject to conditions to be specified hereafter;

D. Student furthermore wishes to enter into the obligation – again taking into account that which was mentioned under (B) – to convey all data collected by him/her as part of the (results of) the Lectureship Study Activities to Fontys and not to retain any copies thereof, and also to return all data, software and/or other means previously provided by Fontys as part of (the results of) the Lectureship Study Activities, such as measuring and testing equipment, to Fontys without retaining copies thereof, all the above being subject to conditions to be specified hereafter.

AGREE THE FOLLOWING

1. Conveyance of intellectual property rights

1.1 Student herewith conveys to the Fontys Paramedic University of Applied Sciences all his/her current and future intellectual property rights and related claims concerning (the results of) the Lectureship Study Activities, for the full term of these rights.

1.2 Intellectual property rights and/or related claims are understood to refer to, in any case – but not limited to – copyright, data bank law, patent law, trademark law, trade name law, designs and model rights, plant breeder's rights, the protection of know-how and protection against unfair competition.

1.3 The conveyance described under 1.1 shall be without restriction. As such, the aforesaid conveyance shall include all competences related to the conveyed rights and claims, and said conveyance shall apply to all countries worldwide.

1.4 Insofar as any national law requires any further cooperation on the part of Student for the conveyance mentioned under 1.1, Student will immediately and without reservation lend such cooperation at first request by Fontys Paramedic University of Applied Sciences

1.5 Fontys accepts the conveyance described under 1.1.

2. Waiver of personal rights

2.1 Insofar as permitted under article 25 'Copyright' and any other national laws that may apply, Student waives his/her personal rights, including – but not limited to – the right to mention Student's name and the right to oppose any changes to (the results of) the Lectureship Study Activities. If and insofar as Student can claim personality rights pursuant to any national laws notwithstanding the above, Student will not appeal to said personality rights on unreasonable grounds.

2.2 In deviation from that which was stipulated under 2.1, the Fontys Paramedic University of Applied Sciences may decide to mention the name of Student if this is reasonable in view of the extent of his/her contribution and activities.

3. Compensation

Student agrees that he/she will receive no compensation for the conveyance and waiver of rights as described in this Statement.

4. Guarantee concerning intellectual property rights

Student declares that he/she is entitled to the aforesaid conveyance and waiver, and declares that he/she has not granted or will grant in future, license(s) for the use of (the results of) the Lectureship Study Activities in any way to any third party/parties. Student indemnifies Fontys from any claims by third parties within this context.

5. Obligation to convey/return data, software and other means

5.1 At such a time as Student is no longer performing any Lectureship Study Activities and/or is no longer a student at Fontys, Student is obliged to convey to Fontys all data, in the widest sense of the word, collected by him/her as part of (results of) the Lectureship Study Activities, including – but not limited to – studies and research results, interim notes, documents, images, drawings, models, prototypes, specifications, production methods, process descriptions and technique descriptions.

5.2 Student guarantees not to have kept any copies in any way or form of the data meant under 5.1.

5.3 Student is obliged to return to Fontys all data, software and other means provided to him/her by Fontys as part of the Lectureship Study Activities, and guarantees not to have kept copies in any way or in any form, of the provided software and/or other means.

5.4 Student agrees that if he acts and/or proves to have acted contrary to the obligations mentioned under 5.1 up to and including 5.3, (a) he/she shall be liable for all and any damages incurred or to be incurred by Fontys, and (b) that this will qualify as fraud and that Fontys can apply the appropriate sanctions hereto. The sanctions to be applied by Fontys may consist of, among other things, the denying of study credits, the temporary exclusion of the Undersigned from participation in examinations, but also the definitive removal of the registration of the Undersigned as a student at Fontys.

6. Waiver

Student waives the right to terminate this Agreement.

7. Further stipulations

7.1 Insofar as this Agreement deviates from the Student Statute, this Agreement shall prevail.

7.2 This Agreement is subject to Dutch law. All disputes resulting from this statement will be brought before the competent judge in Amsterdam.

Student:	**Fontys Institute trading under the name Fontys Hogescholen Supervisor:**
Name: ___________________________	Name: ______________________________
________________________________ (signature) Date:__/__/____ Place: ____________________	______________________________ (signature) Date:__/__/____ Place: ____________________

I, Ms. M.H. de Waard, sworn translator for the English language registered at the Court in Groningen, the Netherlands, and registered in the Dutch Register of Sworn Translators and Interpreters (Rbtv) under nr. 2202, herewith certify the above to be a true and faithful translation of the attached Dutch document into the English language. Groningen, 23 May 2012, [M.H. de Waard]

XII. Descriptive Analysis

Table: Test of Normality for static balance with visual feedback (1st)

	Shapiro-Wilk		
	Statistic	df	Sig.
Balance_Perf1	.925	33	.025
Balance_Perf2	.909	33	.009
Avg_Front1a	.963	33	.319
Avg_Front2a	.932	33	.041
Avg_Back1a	.883	33	.002
Avg_Back2a	.903	33	.006
Avg_Left1a	.925	33	.025
Avg_Left2a	.936	33	.051
Avg_Right1a	.985	33	.913
Avg_Right2a	.916	33	.014

Table: Descriptive Analysis of variables from the static balance with visual feedback (1st)

		Balance_Perf1	Balance_Perf2	Avg_Front1a	Avg_Front2a	Avg_Back1a	Avg_Back2a	Avg_Left1a	Avg_Left2a	Avg_Right1a	Avg_Right2a
N		33	33	33	33	33	33	33	33	33	33
Mean		92.03	91.73	.70	.79	-.88	-.91	-.73	-.71	.66	.70
Median		93.00	92.00	.67	.72	-.72	-.87	-.67	-.72	.65	.65
Std. Deviation		2.34	2.21	.21	.25	.37	.35	.25	.21	.21	.19
Range		8.00	10.00	.98	1.09	1.20	1.74	1.24	.79	.94	.76
Minimum		87.00	85.00	.31	.31	-1.64	-2.09	-1.57	-1.18	.24	.44
Maximum		95.00	95.00	1.29	1.40	-.44	-.35	-.33	-.39	1.18	1.20
Percentiles	25	90.00	90.5	.55	.60	-1.11	-1.07	-.89	-.89	.55	.58
	50	93.00	92.00	.67	.72	-.72	-.87	-.67	-.72	.65	.65
	75	94.00	93.00	.86	.94	-.59	-.64	-.60	-.53	.82	.82

Table: Test of Normality for static balance, proprioception without visual feedback (2nd)

	Shapiro-Wilk		
	Statistic	df	Sig.
Proprioception_Perf1	.959	33	.240
Proprioception_Perf2	.907	33	.008
Avg_Front1b	.808	33	.000
Avg_Front2b	.924	33	.023
Avg_Back1b	.880	33	.002
Avg_Back2b	.909	33	.009
Avg_Left1b	.923	33	.022
Avg_Left2b	.967	33	.407
Avg_Right1b	.897	33	.004
Avg_Right2b	.937	33	.055

Table: Descriptive Analysis of variables from the static balance, proprioception without visual feedback (2nd)

		Proprioception_Perf1	Proprioception_Perf2	Avg_Front1b	Avg_Front2b	Avg_Back1b	Avg_Back2b	Avg_Left1b	Avg_Left2b	Avg_Right1b	Avg_Right2b
N		33	33	33	33	33	33	33	33	33	33
Mean		86.64	88.06	.97	.96	-1.47	-1.21	-.95	-.72	.87	1.07
Median		88.00	89.00	.75	.85	-1.28	-1.07	-.78	-.68	.70	1.02
Std. Deviation		4.94	4.33	.77	.43	.75	.63	.50	.32	.49	.46
Range		20.00	16.00	3.85	1.85	2.86	2.95	1.79	1.35	1.75	1.77
Minimum		76.00	77.00	.13	.34	-3,20	-3.25	-2.06	-1.51	.13	.48
Maximum		96.00	93.00	3.98	2.19	-.34	-.30	-.27	-.16	1.88	2.25
Percentiles	25	83.00	85.00	.44	.57	-1.68	-1.56	-1.36	-.94	.52	.64
	50	88.00	89.00	.75	.85	-1.28	-1.07	-.78	-.68	.70	1.02
	75	90.00	92.00	1.21	1.27	-1.03	-.78	-.60	-.45	1.21	1.41

Table: Test of Normality for dynamic left-right (3rd)

	Shapiro-Wilk		
	Statistic	df	Sig.
LeftRight_Perf1	.982	33	.849
LeftRight_Perf2	.965	33	.352
InsFront1	.970	33	.476
InsFront2	.964	33	.341
InsBack1	.992	33	.996
InsBack2	.936	33	.052
Avg_Front1c	.791	33	.000
Avg_Front2c	.925	33	.025
Avg_Back1c	.979	33	.747
Avg_Back2c	.946	33	.101
Avg_Left1c	.950	33	.135
Avg_Left2c	.961	33	.284
Avg_Right1c	.951	33	.142
Avg_Right2c	.932	33	.041

Table: Descriptive Analysis of variables from the dynamic left-right (3rd)

		LeftRight_Perf1	LeftRight_Perf2	InsFront1	InsFront2	InsBack1	InsBack2	Avg_Front1c	Avg_Front2c	Avg_Back1c	Avg_Back2c	Avg_Left1c	Avg_Left2c	Avg_Right1c	Avg_Right2c
N		33	33	33	33	33	33	33	33	33	33	33	33	33	33
Mean		48.48	42.91	23.03	20.91	25.42	21.94	1.33	1.48	-1.50	-1.77	-6.61	-7.80	6.51	7.50
Median		48.00	41.00	22.00	20.00	25.00	21.00	1.26	1.48	-1.49	-1.69	-6.72	-7.44	6.46	7.32
Std. Deviation		9.70	9.47	5.60	5.61	5.52	5.22	.41	.39	.38	.51	1.55	2.31	1.46	2.31
Range		42.00	41.00	23.00	28.00	25.00	20.00	2.14	1.78	1.56	2.09	6.93	8.94	6.59	10.04
Minimum		28.00	23.00	14.00	9.00	13.00	14.00	.82	.90	-2.36	-3.03	-11.00	-12.74	4.03	3.69
Maximum		70.00	64.00	37.00	37.00	38.00	34.00	2.96	2.68	-.80	-.94	-4.07	-3.80	10.62	13.73
Percentiles	25	41.50	36,50	19.50	17.00	22.00	18.50	1.08	1.18	-1.77	-2.15	-7.74	-9.16	5.43	6.57
	50	48.00	41.00	22.00	20.00	25.00	21.00	1.26	1.48	-1.49	-1.69	-6.72	-7.44	6.46	7.32
	75	54.00	51.50	27.50	24.00	30.00	24.50	1.44	1.68	-1.22	-1.39	-5.49	-6.14	7.08	8.37

Table: Test of Normality for dynamic front-back (4th)

	Shapiro-Wilk		
	Statistic	df	Sig.
FrontBack_Perf1d	.977	33	.683
FrontBack_Perf2d	.923	33	.022
InsLeft1d	.955	33	.192
InsLeft2d	.972	33	.539
InsRight1d	.967	33	.399
InsRight2d	.964	33	.328
Avg_Front1d	.913	33	.012
Avg_Front2d	.948	33	.114
Avg_Back1d	.955	33	.185
Avg_Back2d	.948	33	.120
Avg_Left1d	.880	33	.002
Avg_Left2d	.913	33	.011
Avg_Right1d	.883	33	.002
Avg_Right2d	.908	33	.009

Table: Descriptive Analysis of variables from the dynamic front-back (4th)

		FrontBack_Perf1d	FrontBack_Perf2d	InsLeft1d	InsLeft2d	InsRight1d	InsRight2d	Avg_Front1d	Avg_Front2d	Avg_Back1d	Avg_Back2d	Avg_Left1d	Avg_Left2d	Avg_Right1d	Avg_Right2d
N		33	33	33	33	33	33	33	33	33	33	33	33	33	33
Mean		52.97	50.55	26.48	24.82	26.52	25.76	6.72	7.73	-6.81	-7.99	-1.41	-1.35	1.32	1.42
Median		54.00	53.00	26.00	26.00	27.00	25.00	6.24	7.46	-6.56	-7.50	-1.32	-1.28	1.24	1.31
Std. Dev.		10.63	10.72	5.91	6.03	6.51	6.27	1.77	1.89	2.10	2.31	.50	.44	.51	.51
Range		48.00	37.00	25.00	26.00	33.00	22.00	7.26	8.54	7.28	8.38	2.60	1.88	2.28	2.05
Minimum		33.00	27.00	17.00	10.00	13.00	14.00	4.35	4.53	-11.04	-12.88	-3.23	-2.66	.57	.75
Maximum		81.00	64.00	42.00	36.00	46.00	36.00	11.61	13.07	-3.76	-4.50	-.63	-.78	2.85	2.80
	25	44.50	41.50	21.50	21.00	23.00	21.00	5,50	6.49	-8.33	-9.85	-1.58	-1.51	.98	1.04
Percentiles	50	54.00	53.00	26.00	26.00	27.00	25.00	6.24	7.46	-6.56	-7.50	-1.32	-1.28	1.24	1.31
	75	58.00	61.00	30.50	29.00	29.50	31.50	7.74	8.53	-4.96	-6.00	-1.10	-.98	1.48	1.72

Table: Test of Normality for dynamic cross-diagonal (5th)

	Shapiro-Wilk		
	Statistic	df	Sig.
CrossD_Perf1e	.984	33	.906
CrossD_Perf2e	.967	33	.395

Table: Descriptive Analysis of variables from the dynamic cross-diagonal (5th)

		CrossD_Perf1e	CrossD_Perf2e
N		33	33
Mean		45.76	43.12
Median		47.00	46.00
Std. Deviation		8.14	9.55
Range		32.00	41.00
Minimum		29.00	20.00
Maximum		61.00	61.00
	25	39.50	36.50
Percentiles	50	47.00	46.00
	75	52.00	51.00

Table: Test of Normality for dynamic donut (6th)

	Shapiro-Wilk		
	Statistic	df	Sig.
Donut_Perf1f	.967	33	.406
Donut_Perf2f	.965	33	.356
DevInsPath1f	.981	33	.809
DevInsPath2f	.978	33	.713
DevOutPath1f	.961	33	.279
DevOutPath2f	.970	33	.469

Table: Descriptive Analysis of variables from the dynamic donut (6^{th})

		Donut_Perf1f	Donut_Perf2f	DevInsPath1f	DevInsPath2f	DevOutPath1f	DevOutPath2f
N		33	33	33	33	33	33
Mean		62.61	62.00	24.79	25.21	12.55	12.85
Median		61.00	61.00	27.00	25.00	13.00	14.00
Std. Deviation		9.49	7,45	7.29	7.35	5.58	5.83
Range		37.00	32.00	31.00	35.00	21.00	22.00
Minimum		45.00	49.00	9.00	8.00	3.00	1.00
Maximum		82.00	81.00	40.00	43.00	24.00	23.00
	25	56.00	58.00	19,50	19.50	7.50	7.50
Percentiles	50	61.00	61.00	27.00	25.00	13.00	14.00
	75	68.00	66.00	30.00	29.00	16.00	17.50

Table: Test of Normality for dynamic circle (7^{th})

	Shapiro-Wilk		
	Statistic	df	Sig.
Circle_Perf1g	.974	33	.606
Circle_Perf2g	.931	33	.038

Table: Descriptive Analysis of variables from the dynamic circle (7^{th})

		Circle_Perf1g	Circle_Perf2g
N	Valid	33.00	33.00
Mean		78.73	77.42
Median		80.00	79.00
Std. Deviation		9.37	9.14
Range		37.00	31.00
Minimum		58.00	61.00
Maximum		95.00	92.00
	25	73.00	68.00
Percentiles	50	80.00	79.00
	75	85.00	85.00

XIII. Correlational Analysis

Table: ICC of variable performance in percentage of the static balance with visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.642[a]	.390	.805	.000
Average Measures	.782[c]	.561	.892	.000

Table: ICC of variable average tilt to the front in degrees of the static balance with visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.601[a]	.313	.784	.000
Average Measures	.751[c]	.477	.879	.000

Table: ICC of variable average tilt to the back in degrees of the static balance with visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.461[a]	.142	.693	.003
Average Measures	.631[c]	.249	.819	.003

Table: ICC of variable average tilt to the left in degrees of the static balance with visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.516[a]	.215	.728	.001
Average Measures	.681[c]	.354	.842	.001

Table: ICC of variable average tilt to the right in degrees of the static balance with visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.546[a]	.257	.746	.000
Average Measures	.706[c]	.409	.854	.000

Table: ICC of variable performance in percentage of the static balance, proprioception without visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.356[a]	.033	.616	.017
Average Measures	.525[c]	.064	.762	.017

Table: ICC of variable average tilt to the front in degrees of the static balance, proprioception without visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.114[a]	-.246	.441	.266
Average Measures	.204[c]	-.652	.612	.266

Table: ICC of variable average tilt to the back in degrees of the static balance, proprioception without visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		Sig
		Lower Bound	Upper Bound	
Single Measures	.415[a]	.104	.656	.005
Average Measures	.586[c]	.188	.792	.005

Table: ICC of variable average tilt to the left in degrees of the static balance, proprioception without visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.294[a]	-.016	.564	.027
Average Measures	.455[c]	-.033	.721	.027

Table: ICC of variable average tilt to the right in degrees of the static balance, proprioception without visual feedback

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.423[a]	.112	.662	.004
Average Measures	.594[c]	.202	.797	.004

Table: ICC of variable performance in percentage of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.452[a]	.108	.693	.001
Average Measures	.622[c]	.194	.819	.001

Table: ICC of variable inside front in percentage of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.476[a]	.173	.699	.001
Average Measures	.645[c]	.296	.823	.001

Table: ICC of variable inside back in percentage of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.286[a]	-.023	.558	.024
Average Measures	.445[c]	-.048	.716	.024

Table: ICC of variable average tilt to the front in degrees of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.381[a]	.066	.632	.010
Average Measures	.552[c]	.123	.775	.010

Table: ICC of variable average tilt to the back in degrees of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.476[a]	.107	.717	.000
Average Measures	.645[c]	.193	.835	.000

Table: ICC of variable average tilt to the left in degrees of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.484[a]	.116	.722	.000
Average Measures	.652[c]	.207	.839	.000

Table: ICC of variable average tilt to the right in degrees of the dynamic left-right

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.591[a]	.232	.792	.000
Average Measures	.743[c]	.377	.884	.000

Table: ICC of variable performance in percentage of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.506[a]	.209	.720	.001
Average Measures	.672[c]	.346	.837	.001

Table: ICC of variable inside left in percentage of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.461[a]	.155	.689	.002
Average Measures	.631[c]	.269	.816	.002

Table: ICC of variable inside right in percentage of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.434[a]	.109	.674	.006
Average Measures	.605[c]	.197	.805	.006

Table: ICC of variable average tilt to the front in degrees of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.625[a]	.211	.823	.000
Average Measures	.769[c]	.348	.903	.000

Table: ICC of variable tilt to the back in degrees of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.770[a]	.116	.921	.000
Average Measures	.870[c]	.208	.959	.000

Table: ICC of variable average tilt to the left in degrees of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.600[a]	.329	.780	.000
Average Measures	.750[c]	.495	.876	.000

Table: ICC of variable average tilt to the right in degrees of the dynamic front-back

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.322[a]	-.018	.595	.032
Average Measures	.487[c]	-.036	.746	.032

Table: ICC of variable performance in percentage of the dynamic cross-diagonal

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.569[a]	.291	.760	.000
Average Measures	.725[c]	.450	.863	.000

Table: ICC of variable performance in percentage of the dynamic donut

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.233[a]	-.124	.533	.098
Average Measures	.377[c]	-.282	.695	.098

Table: ICC of variable deviation from the path towards the inside of the dynamic donut

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.387[a]	.049	.643	.013
Average Measures	.558[c]	.093	.783	.013

Table: ICC of variable deviation from the path towards the outside of the dynamic donut

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.529[a]	.227	.737	.001
Average Measures	.692[c]	.371	.848	.001

Table: ICC of variable performance in percentage of the dynamic circle

	Intraclass Correlation[b]	95% Confidence Interval		
		Lower Bound	Upper Bound	Sig
Single Measures	.487[a]	.178	.709	.002
Average Measures	.655[c]	.303	.830	.002