RELIABILITY FOR VIRTUALIS - STATIC & DYNAMIC BALANCE POSTUROGRAPHY IN HEALTY YOUNG SUBJECTS

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Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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ABSTRACT

Background: Posturography is the gold standard for the assessment of sensory and motor contributions to postural control. With technological advancements, such systems are constantly being renewed. Unlike other measurement methods, Virtualis - Static & Dynamic Posturography is used for evaluation and treatment purposes.

Research question: The aim of our study is to ensure the safe use of the Virtualis- Static & Dynamic Posturography in clinics like other devices and to test its validity and reliability.

Methods: In this study, 30 healthy participants underwent Sensory Organization Test (SOT), Motor control test (MCT) and Adaptation test, AT, administered by two different researchers (Rater 1 two times, Rater 2 one time) on the same day each week.

Results: Seventeen males and thirteen females, a total of 30 with an age range of 18 to 40 years (25.63 ±6.59), participated in the study. In the evaluations conducted between the two audiologists, it was confirmed that there was no statistical difference between the measurements ($p>0.05$). The measurement differences of the evaluators adhered to the assumption of normal distribution ($p>0.05$) and no statistically significant difference was observed between the averages of the evaluators and their differences ($p>0.05$).

Significance: This study has determined that the use of the Sensory Organization Test (SOT), Motor Control Test (MCT), and Adaptation Test (AT) as a test battery for assessing the balance system in healthy young adults using the Virtualis - Static & Dynamic Posturography is valid and reliable.

Keywords: posturography, Virtualis - Static & Dynamic Posturography, reliability

Introduction

Balance, determined by input from visual, vestibular, somatosensory, cognitive, and emotional systems, is the ability to maintain the center of gravity in the base of support [1]. Dynamic and static balance are the components of balance. Static and dynamic changes in the balance system are called postural sway [2].

Postural control is a central nervous system feedback control system and governs human upright stance [3]. There are lots of computerized dynamic systems which are used for the evaluation balance Sensory Organization Test (SOT), Motor control test (MCT) and adaptation test which are the assesments of balance, sensitive to subtle, persistent deficits in postural control [4]. Posturography is the gold standard for the assessment of sensory and motor contributions to postural control. Neurocom is one of the posturography systems that is used safely and reliably in evaluation and rehabilitation in a variety of populations like children, aging adults, soldiers, athletes, and clinic groups who have vertigo, Parkinson's disease, and Alzheimer's disease [5]. Although dynamic posturography can shed insight into the type of balance disorder, functional compensation, and the likely environments leading to instability for individual subjects, it is not a diagnostic tool [6]. This system may assess how each sensory system contributes to balance control and how well subjects can reweight the available sensory information necessary to maintain balance in altered environments [7]. The dynamic posturography system provides a balance score (how little participants swayed) during each test, as well as a sensory analysis score (how much they relied on each system) and strategy analysis (the hip or ankle strategy) [5].

With technological advancements, such systems are constantly being renewed. Similar to other measurement methods, Virtualis - Static & Dynamic Posturography is used for evaluation and treatment. Virtual reality, one of the technological developments, is a material used in the evaluation of the vestibular system and innovations in this field are important to us because there isnt any system which use virtual reality in posturography. The Virtualis - Static & Dynamic Posturography is the first technology, use virtual reality in diagnosis and treatment. The aim of our study is to ensure the safe use of this device in clinics, as with other devices, and to test its validity and reliability to pave the way for new research.

Methods

This study was carried out at the Hearing and Balance Center at the XXX University between December 2023 to May 2024. The sample size was calculated by using the G*Power (3.1.9.3) software, and according to the result of the power analysis (%95 power, 0.005), a total of 30 participants were included in the study.

Seventeen males and thirteen females, a total of 30 with an age range of 18 to 40 years (25.63 ±6.59), participated in the study. The test was conducted on healthy young participants without any balance disorders. Inclusion criteria for the study were defined as being between 18-40 years old, being healthy, and showing voluntary participation. Exclusion criteria were determined as being under 18 and over 40 years old, having vestibular disorders, orthopedic disorders, neuropathy, or any disease that would disrupt the balance system. For the study, approval was received from the XXX University Institutional Review Board and Ethics Committee (2024/31). Each individual participating in the study was informed about it and signed an informed consent form.

Test Protocol

Two audiologists (Rater-1 and Rater-2) tested each subject three times (one trial a week). Rater 1 tested two times, and Rater 2 tested once on the same day each week. The virtualis testing included the SOT, MCT, and Adaptation Test, per manufacturer guidelines. All trials duration was 20 seconds. Subjects were positioned barefoot, wearing virtual reality and loosely fitting safety. In each session, the subject completed all test protocols (SOT, MCT, AT). The device calibration was performed before starting the test. During the test, the participants were instructed to comply with the tasks according to the test position.

Instrumentation

The Virtualis - Static & Dynamic Posturography (France) device was developed by Franck Assaban in 2015 to use virtual reality in diagnosis and treatment. Similar to computer-based posturography devices, Virtualis - Static & Dynamic Posturography objectively evaluates static and dynamic balance tests.

All participants completed assessments of postural sway on both the Virtualis - Static & Dynamic Posturography Balance System, a computerized and virtual reality system designed for static and dynamic balance assessment and training. Three tests have been analyzed, which are Sensory Organization Test, Motor Control Test, and Adaptation Test (Figure 1).

Sensory Organization Test

Implementing the sensory organization test (SOT) using the computerized system requires individuals to process and integrate cues from the visual, vestibular, and proprioceptive system. This test provides clinicians and researchers with an equilibrium score for each tested condition, a sensory analysis score, a strategy analysis, and a center of gravity alignment [5]. Test has six different conditions which have been analyzed from basic to difficult balance performance. The conditions during the clinical test included eyes open on a stable surface, eyes closed on a stable surface, eyes open with sway-referenced surround, eyes open on a sway-referenced surface, eyes closed on a sway-referenced surface, and eyes open with both a sway-referenced surround and surface [8]. Parameters evaluated in virtualis posturography computerized systems are composite, somesthesia, visual, vestibular, visual, preference.

Motor Control Test

Motor control test determines the individual's ability and competence against unexpected, sudden stimuli. Response times are assessed using motor control test backward (small-medium-large) and forward (small-medium-large) [9].

Adaptation test

The adaptation test measures the individual's response to an unstable support surface. The platform automatically moves anterior-posterior randomly for periods of 3 or 5 seconds, and this is tested for a reaction of postural stability. As a result of the test, an adaptation score is obtained [10].

Statistical Analysis

The study data were transferred to IBM SPSS Statistics version 26.0 (IBM, Armonk, NY, USA) for analysis, and the analyses were completed. Descriptive statistics (mean, standard deviation) were provided for numerical variables during data evaluation. Differences between more than two dependent groups (Rater 1 first measurement, Rater 1 second measurement, Rater 2 measurement) based on measurements were examined using repeated measures analysis of variance. The Bland-Altman Method was used to determine the agreement between Rater 1 and Rater 2 evaluators. Before applying the Bland-Altman method, it was examined whether the measurement differences of the observers met the assumption of normal distribution and whether there was a significant relationship between the measurement differences of the observers and the measurement averages of the observers.

Results

In this study no statistically significant difference was observed in the averages of composite, somestasia, visual, vestibular, visual preference, toes down, toes up, backward, forward, and C measurement values between Rater 1 (first and second measurement) and Rater 2 ($p>0.05$) (Table 1).

The measurement differences of the evaluators adhered to the assumption of normal distribution ($p>0.05$) and no statistically significant difference was observed between the averages of the evaluators and their differences ($p>0.05$) (Table 2).

Bland-Altman graph results showed concordance between the measurements of the two evaluators for the SOT graph (Figure 2), AT graph (Figure 3), and MCT graph (Figure 4).

Discussion

The advancement of technology contributes to the development of products used in the healthcare sector. Virtual reality applications are one of the innovations used in the healthcare industry in recent years. As a computer-assisted program, virtual reality (VR) provides real-time simulation and interaction through various sensory channels such as vision, hearing, touch, smell, and taste. The combination of VR with wearable technology further amplifies its utility, making it accessible and practical for various applications. When combined with wearable technology, virtual reality has a wide range of applications and proves reliable, easy, and applicable. In recent studies, taking advantage of technology, many new devices have been developed for diagnostic and therapeutic applications. One of these devices is the virtualis posturography device [13,14]. Various models of computerized posturography are used in the literature, and validity and reliability studies of these devices have been conducted. With this study, we aimed to evaluate the validity and reliability of the newly developed posturography device in healthy individuals. Virtualis - Static &Dinamic Posturography, which is the newest one of the CDP is understandable and useful for clinicians. According our findings that the Sensory Organization Test (SOT), Motor Control Test (MCT), and Adaptation Test (AT) as a test battery for assessing the balance system in healthy young adults using the Virtualis - Static & Dynamic Posturography is valid and reliable.

Posturography is indeed crucial for evaluating postural control and stability. It involves assessing the interplay between sensory systems like vision, vestibular function, and somatosensation. This evaluation can occur under static or dynamic conditions. The methods range from simple clinical tests to advanced computerized systems like Computerized Dynamic Posturography (CDP). Computerized posturography is nowadays the gold standard for the instrumented balance assessment, which is both valid and reliable [11]. CDP is calculated to the center of pressure (COP) of the subject on the platform over time, serving as a reliable indicator of the subject's center of gravity projection during slow movements [12], so it has been the objective and quantitative assessment of balance in a standardized. CDP allows an understanding of the physiology and pathophysiology of postural control by studying groups of healthy subjects or patients [6].

Olchowick et al. [15] evaluated the relationship between gender and balance using a computerized dynamic posturography device. The authors found that gender did not affect balance or normative data in healthy young individuals [15]. In our study, evaluation was conducted without gender distinction, and the posturography device used was valid and reliable.

Various models of computerized posturography are used in the literature, and validity and reliability studies of these devices have been conducted. The computerized posturography device used in the study 'Normative data for static balance testing in healthy individuals using open source computerized posturography' has been reported as an appropriate and reliable testing method [12]. In the study we found that there was no statistically significant difference in the averages of composite, somestasia, visual, vestibular, visual preference, toes down, toes up, backward, forward, and C measurement values between Rater 1 (first and second measurement) and Rater 2. Madenci et al. [4] compared the normalization of the Biodex BioSway device with the Neurocom posturography device. They reported high reliability between the BioSway and Neurocom devices, indicating that the BioSway device is an appropriate measurement tool [4]. In our study evaluating the validity and reliability of the virtual reality-based posturography device, we found the virtual reality posturography to be valid and reliable.

As a limitation of our study, the device was used for normalization in clinical use. We believe that studies exploring its application in various diseases and the results obtained would provide more valuable insights.

This is the first study to investigate the validity of the Virtualis- Static &Dinamic Posturography in quantifying postural sway. The most important difference between virtual reality and CPD is the utilization of virtual reality for visual perception. Despite hardware and technological differences between the systems, virtual reality posturography provides similar measurement tests (such as SOT, MCT, AT) and result information as other posturography devices.

Conclusion

In conclusion, this study has determined that the useful of the Sensory Organization Test (SOT), Motor Control Test (MCT), and Adaptation Test (AT) as a test battery for assessing the balance system in healthy young adults using the Virtualis- Static &Dinamic Posturography is valid and reliable. It can be utilized for posturography assessment in different age groups and populations, indicating the need for further research.

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Table captions

Table 1. Comparison of values of tests.

Table 2. Results Regarding Bland-Altman Values.

Figure captions

Figure 1. Picture of a test using the Virtualis - Static &Dinamic Posturography system.

Figure 2. Bland-Altman comparison graphs of SOT

A. Bland Altman plot for comparison of SOT X and Y composite measurements.

B. Bland Altman plot for comparison of SOT X and Y somestesia measurements.

C. Bland Altman plot for comparison of SOT X and Y visual measurements.

D. Bland Altman plot for comparison of SOT X and Y vestibular measurements.

E. Bland Altman plot for comparison of SOT X and Y visual preference measurements.

Figure 3. Bland-Altman comparison graphs of AT test

A. Bland Altman plot for comparison of AT X and Y toes down measurements.

B. Bland Altman plot for comparison of AT X and Y toes up measurements

Figure 4. Bland-Altman comparison graphs of MCT

A. Bland Altman plot for comparison of AT X and Y backwardleft mean measurements.

B. Bland Altman plot for comparison of AT X and Y backwardright mean measurements.

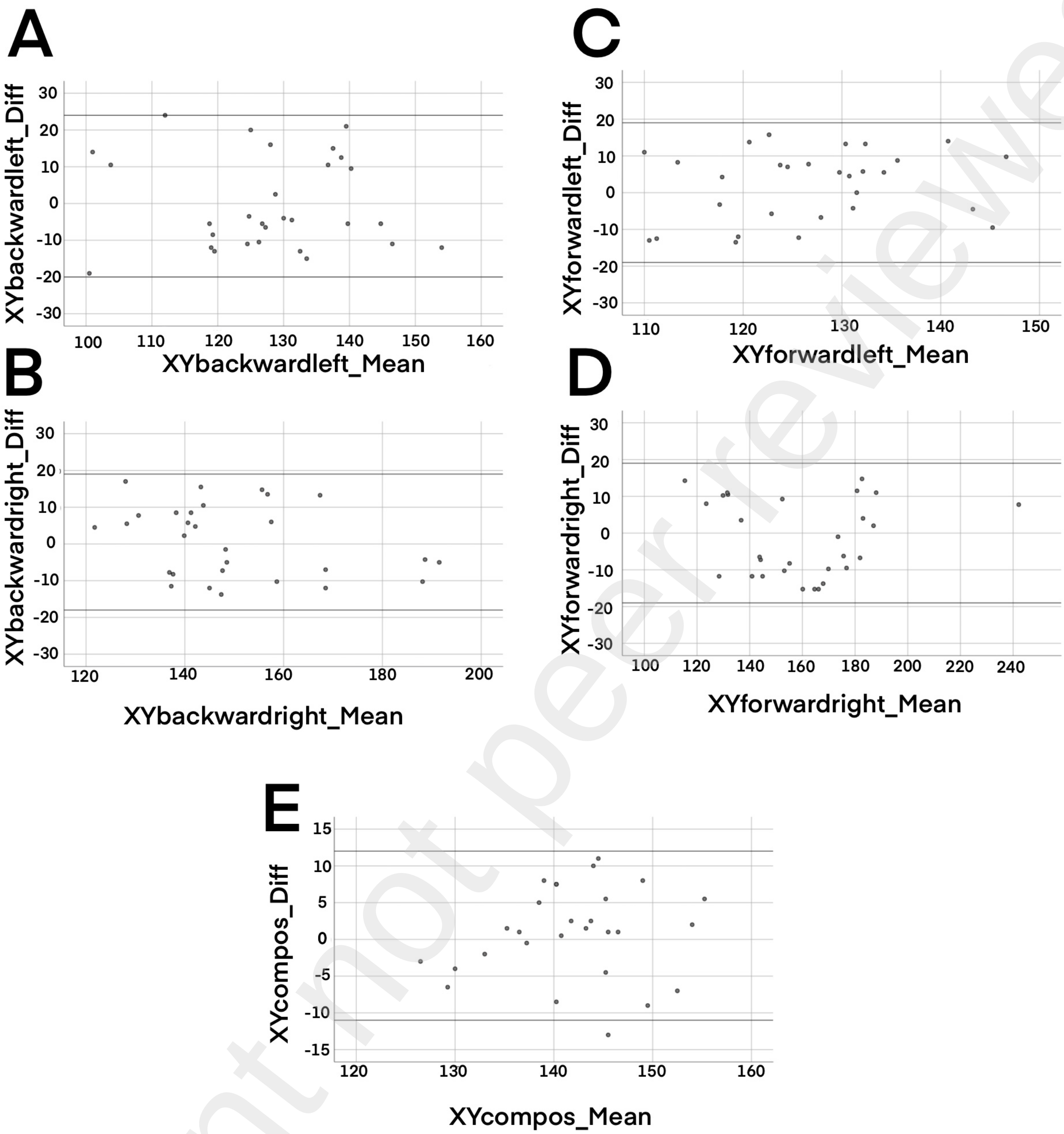
C. Bland Altman plot for comparison of AT X and Y forwardleft mean measurements.

D. Bland Altman plot for comparison of AT X and Y forwardright mean measurements.

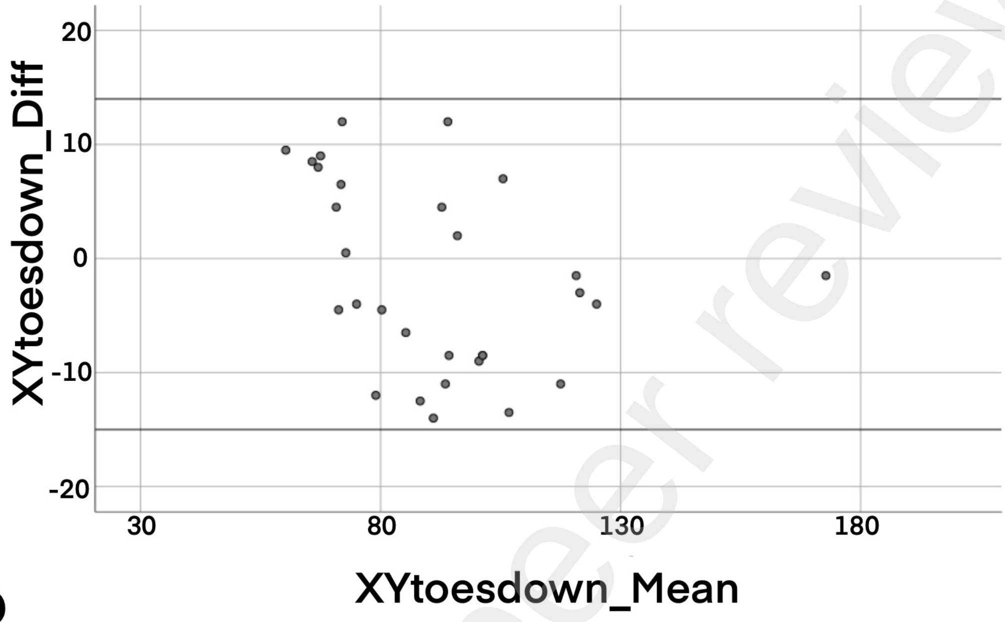
E. Bland Altman plot for comparison of AT X and Y compos mean measurements.

Conflict of Interests

The authors have no conflict of interests to declare.

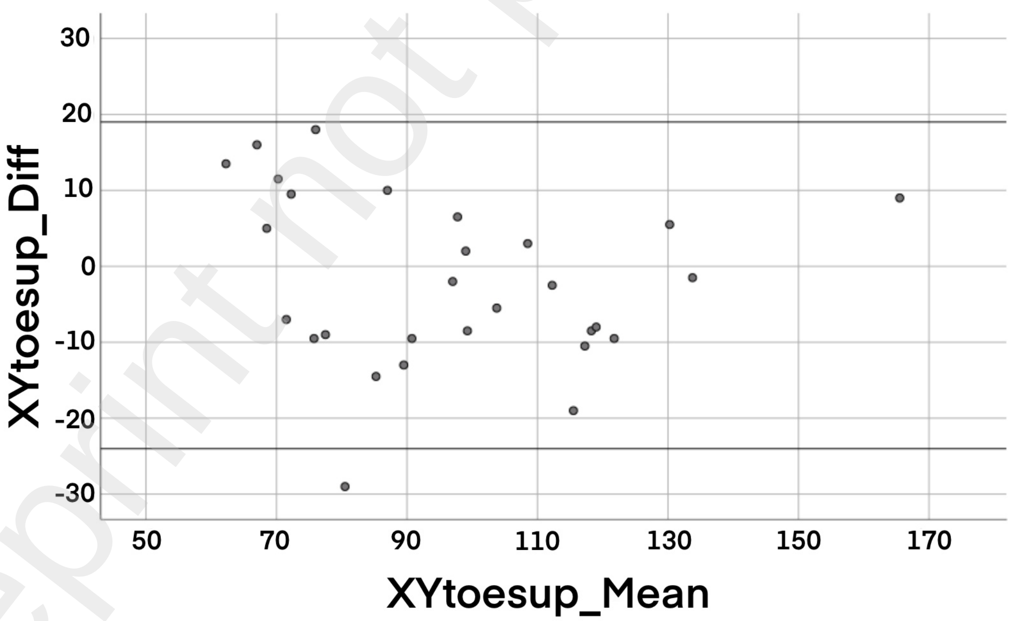

A
XYbackwardleft_Diff
XYbackwardleft_Mean
B
XYbackwardright_Diff
XYbackwardright_Mean
C
XYforwardleft_Diff
XYforwardleft_Mean
D
XYforwardright_Diff
XYforwardright_Mean
E
XYcompos_Diff
XYcompos_Mean

A

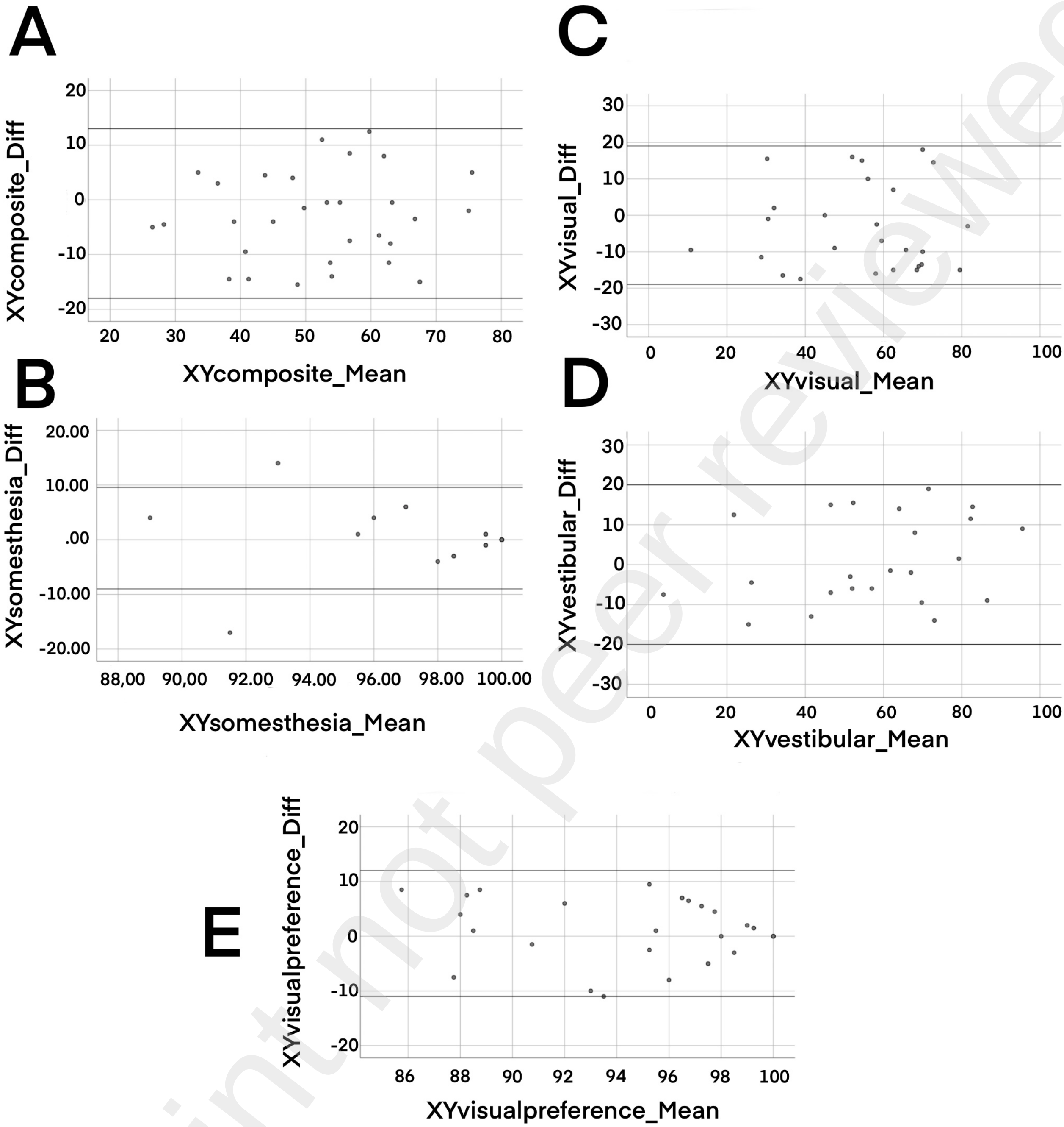


XYtoesdown_Diff
20
10
0
-10
-20
30
80
130
180
XYtoesdown_Mean

B



XYtoesup_Diff
30
20
10
0
-10
-20
-30
50
70
90
110
130
150
170
XYtoesup_Mean


A
XYcomposite_Diff
XYcomposite_Mean
20
10
0
-10
-20
20
30
40
50
60
70
80
B
XYsomesthesia_Diff
XYsomesthesia_Mean
20.00
10.00
.00
-10.00
-20.00
88,00
90,00
92.00
94.00
96.00
98.00
100.00
C
XYvisual_Diff
XYvisual_Mean
30
20
10
0
-10
-20
-30
0
20
40
60
80
100
D
XYvestibular_Diff
XYvestibular_Mean
30
20
10
0
-10
-20
-30
0
20
40
60
80
100
E
XYvisualpreference_Diff
XYvisualpreference_Mean
20
10
0
-10
-20
86
88
90
92
94
96
98
100

		X mean±sd	Y mean±sd	Bland Altman Values			
				Mean Difference (MD)	Standard deviation (SD)	Agreement limits (MD ± 1,96*SD)	
1	Composite	51,94±12,809	50,40±13,793	-3,08	8,135	-19,03	12,86
2	Somestasia	98,60±1,823	98,90±2,335	0,59	3,687	-6,64	7,81
3	Visual	54,14±18,069	52,46±19,002	-3,37	11,934	-26,76	20,03
4	Vestibular	57,64±22,977	58,13±25,030	0,98	10,913	-20,41	22,37
5	Visual preference	95,07±4,373	95,53±4,855	0,93	5,653	-10,15	12,01
6	Toes down	92,03±23,686	91,13±22,603	-1,80	8,265	-18,00	14,40
7	Toes up	96,99±24,382	96,00±24,134	-1,98	11,190	-23,91	19,95
8	Backward left (m, l)	127,93±13,023	127,76±14,159	-0,34	12,553	-24,95	24,26
9	Backward right (m, l)	149,91±18,003	150,29±17,150	0,77	9,763	-18,37	19,90
10	Forward left (m, l)	126,81±10,003	128,09±12,068	2,54	11,427	-19,85	24,94
11	Forward right (m, l)	159,70±26,560	159,31±27,559	-0,78	11,824	-23,95	22,40
12	Composite	141,81±7,010	142,34±8,001	1,07	6,145	-10,98	13,11
13	Backward left (s, m, l)	10,18±1,817	10,11±2,083	-0,14	1,484	-3,04	2,77
14	Backward right (s, m, l)	17,93±5,479	18,14±5,751	0,43	2,134	-3,75	4,61
15	Forward left (s, m, l)	10,22±2,050	10,28±2,712	0,11	2,619	-5,02	5,24
16	Forward right (s, m, l)	15,16±3,590	14,97±3,978	-0,38	3,032	-6,32	5,56
17	C (Ort)	59,60±9,589	58,54±9,887	-2,11	4,844	-11,61	7,38

Table 2. Results Regarding Bland-Altman Values.

	X1 mean±sd	X2 mean±sd	Y mean±sd	F; p
Composite	52,37±13,325	54,60±15,467	50,40±13,793	2,228; 0,121
Somestasia	98,17±3,799	98,45±3,572	98,90±2,335	0,382; 0,681
Visual	53,54±21,699	53,39±25,571	52,46±19,002	0,559; 0,537
Vestibular	57,13±22,672	57,17±24,901	58,13±25,030	0,062; 0,925
Visual preference	94,03±7,730	95,17±6,248	95,53±4,855	0,624; 0,518
Toes down	93,87±24,216	92,00±28,107	91,13±22,603	0,891; 0,405
Toes up	101,17±25,490	94,79±28,767	96,00±24,134	2,994; 0,063
Backward left (m, l)	128,76±19,557	127,45±21,194	127,76±14,159	0,054; 0,896
Backward right (m, l)	153,41±36,523	145,64±30,534	150,29±17,15	0,582; 0,462
Forward left (m, l)	126,41±15,322	124,67±17,848	128,09±12,068	0,422; 0,598
Forward right (m, l)	158,00±32,366	162,17±27,955	159,31±27,559	0,551; 0,526
Composite	141,21±10,772	141,34±8,41	142,34±8,001	0,212; 0,753
Backward left (s, m, l)	10,64±1,850	9,83±2,285	10,11±2,083	2,790; 0,077
Backward right (s, m, l)	17,82±5,545	17,61±5,524	18,14±5,751	0,699; 0,497
Forward left (s, m, l)	10,52±2,309	9,82±2,413	10,28±2,712	1,086; 0,339
Forward right (s, m, l)	15,10±3,668	15,59±4,579	14,97±3,978	0,539; 0,585
C1	76,54±11,701	79,57±11,435	73,44±13,155	2,168; 0,126
C2	83,20±5,824	82,40±8,026	83,14±5,495	0,197; 0,797
C3	82,99±6,247	85,37±4,718	82,44±7,836	2,573; 0,085
C4	39,22±18,924	43,16±22,375	34,63±19,522	2,933; 0,061
C5	36,91±21,407	41,81±23,634	34,68±22,177	1,978; 0,148
C6	37,73±25,252	38,22±25,575	32,91±23,134	0,771; 0,467
C (mean)	59,43±9,941	61,88±12,524	58,54±9,887	2,371; 0,119

Table 1. Comparison of mean values and standard deviations of tests.