

Validation of the Wii™ Balance Board for countermovement jump height assessment in healthy adults

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HIGHLIGHTS

- Cross-sectional study comparing jump height via force platform and Wii Balance Board.
- Wii Balance Board showed high reliability but overestimated jump height by 0.92 cm.
- Wii Balance Board is reliable for CMJ height if a correction offset is applied.

ABBREVIATIONS

α	Cronbach's alpha
BMI	Body Mass Index
CI	Confidence Interval
CMJ	Countermovement jump
COP	Center of pressure
ICC	Intraclass Correlation Coefficient
Infini-T P6000	Force platform
MDC95	Minimum Detectable Change
SD	Standard deviation
SEM	Standard Error of Measurement
WBB	Wii™ Balance Board
$\bar{x}$	Mean

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BACKGROUND: Vertical jump height assessment is essential for clinical evaluation and monitoring athletic performance. The force platform (Infini-T P6000) is considered the gold standard, whereas the Wii™ Balance Board (WBB) platform is a low-cost and more accessible alternative yet to be validated.

AIM: To investigate the reliability and agreement between Infini-T P6000 and WBB in measuring vertical jump height.

METHODS: Cross-sectional observational study. Seventy-nine participants performed countermovement jumps on both platforms, in randomized order. Cronbach's alpha was calculated to verify consistency between methods, and intraclass correlation coefficient (ICC: 3,1) to verify consistency and absolute agreement, standard error of measurement (SEM), and minimum detectable change (MDC95). Systematic differences between methods were investigated during the ICC analysis using repeated-measures ANOVA (Between Items) and using Bland–Altman analysis. Statistical significance was set at $p < 0,05$.

RESULTS: Cronbach's alpha was 0.923, indicating excellent internal consistency. The ICC ranged from 0.848 to 0.857, confirming high reliability in both definitions. The repeated-measures ANOVA performed during the ICC test revealed significant systematic differences between the methods [$F(1,78) = 7.514$; $p = 0.008$], with mean jump heights of 15.98 ± 5.72 cm (Infini-T P6000) and 16.90 ± 5.45 cm (WBB), resulting in a systematic bias of +0.92 cm favoring WBB, confirmed by Bland–Altman analysis. SEM was 0.86 cm and $MDC95 \approx 2.38$ cm.

INTERPRETATION: WBB shows high reliability in measuring jump height but systematically overestimates values compared to Infini-T P6000. Although the bias is smaller than the MDC95, it compromises direct interchangeability between methods. Standardization of the measurement device in longitudinal assessments or applying a correction offset (Infini-T P6000 $\approx$ WBB – 0.92) is recommended.

KEYWORDS: Wii Balance Board | Reliability | Agreement | Force Platform | Countermovement Jump

INTRODUCTION

The countermovement jump (CMJ) test is an assessment in which the subject is instructed to perform a rapid squat before jumping, in order to utilize the elastic potential accumulated during the squatting movement^{1,2}. As a maximal performance test involving a rapid movement, the CMJ is frequently associated with a measure of lower-limb explosive strength and, for this reason, is widely used to monitor both functional physical performance and athletic performance^{1,2}.

The versatility of the CMJ can be observed in its use throughout the literature, serving both as a criterion for return to sport after orthopedic injuries³ and as a predictor of sarcopenia and osteoporosis risk in older adults⁴. The jump height in the CMJ, the primary metric used to quantify this test, provides information on lower-limb power¹, the efficiency of the stretch–shortening cycle⁵.

The use of force platforms to measure jump height, as well as other variables related to CMJ performance, is considered the gold standard for instrumentation, as they enable the measurement of forces involved in rapid movements with an appropriate acquisition Frequency⁶. However, the use of force platforms may restrict the applicability of these measures in clinical and sports settings, as their

high acquisition and maintenance costs, requirements for physical space, and dependence on specialized software hinder their implementation outside laboratory environments^{6,7}.

Therefore, considering the importance of the CMJ, alternative methods have been sought to assess performance in this test, including contact mats, motion capture systems, inertial sensors, and smartphone applications for estimating jump height^{8–10}. Nonetheless, the Wii™ Balance Board (WBB) (Nintendo®, Japan), a low-cost and portable device resembling a force platform, has not yet been investigated in the literature as a potential tool to measure jumping performance⁷.

Furthermore, since the Wii™ Balance Board (Nintendo®, Japan) has been widely used to introduce playfulness and gamification in rehabilitation and training processes, it can be easily found in clinics and rehabilitation centers. This ease of access, combined with its low cost compared to other devices, may facilitate the broader use of countermovement jump height assessment in both clinical and research settings.

The WBB (Nintendo®, Japan) has already demonstrated validity and high reliability as an alternative to various instruments, such as force platforms for measuring postural sway through the center of pressure (COP)^{8,11–14}, and as an alternative to dynamometry devices for assessing handgrip strength¹⁵ and isometric lower-limb strength in older adults¹⁶. Thus, the present study aims to examine the reliability and agreement of jump height measurements in the countermovement jump obtained using the WBB (Nintendo®, Japan) compared to a conventional force platform system. Validating the WBB (Nintendo®, Japan) for tests such as the CMJ supports its use as an accessible and feasible tool for field-based monitoring of lower-limb power in research and clinical settings.

METHODS

This cross-sectional observational study was approved by the Ethics Committee for Research Involving Human Subjects of the Santa Catarina State University (CEESH/UDESC) under the protocol number 5.830.520 (CAAE: 65601722.5.0000.0118). The data collection was conducted at the Laboratory of Posture and Balance (LAPEQ), UDESC, between December 2023 and January 2024.

Participants

Healthy adults of both sexes, aged between 18 and 59 years, without musculoskeletal or neurological disorders, and with no self-reported history of lower limb injuries in the last year were invited to participate in this study.

Participants were recruited through flyers on social media and on the university campus. The sample size for the present study was based on similar studies that also validated the WBB (Nintendo®, Japan) measures, where between 30 and 52 participants were evaluated^{11,12,17}.

All participants were asked to read and sign an informed consent form. After signing the informed consent form, participants were evaluated using a characterization form to investigate inclusion and exclusion criteria, as well as characteristics such as sex, age, and height. Body composition was evaluated using a bioelectrical impedance scale (InBody770, InBody Co., South Korea).

Countermovement Jump (CMJ)

The CMJ test was introduced to participants as a movement starting from a standing position on one of the platforms, followed by a quick and shallow squat, followed by an attempt to jump as high as possible. To perform the test, participants were instructed to remove their shoes and socks, keep their hands on their waist throughout the movement, avoiding the use of the upper limbs, and to land in the same spot from which they took off, minimizing anterior–posterior displacement.

They were allowed to perform a squat upon landing to absorb the impact but were required to return to an upright position as quickly as possible. Trials were considered invalid if participants performed a slow squat before take-off, removed their hands from their waist, exhibited excessive anterior–posterior displacement, remained squatting after landing, or showed balance loss upon landing.

One of the researchers demonstrated the jump to each participant, and the participants were allowed to perform up to three repetitions to familiarize themselves with the jumping motion on both platforms. During the familiarization trials, the evaluator provided verbal instructions to correct movement execution. After familiarization, the participants were instructed to perform only one valid repetition of the CMJ on the platforms, Infini-T P6000 (BTS Bioengineering, Italy) and WBB (Nintendo®, Japan). Figure 1 demonstrates the execution of the countermovement jump according to the proposed criteria.

During both practice and valid test attempts on each device, an evaluator remained close to participants but outside their field of vision to intervene if necessary to prevent falls or injuries. Any intervention by the evaluator rendered the trial invalid, and participants were asked to repeat the attempt.

The order of equipment use was randomized by a simple draw. The WBB (Nintendo®, Japan) was connected to a laptop via Bluetooth, and vertical force data were acquired using the BrainBlox software¹⁸ at a sampling frequency of 200 Hz.

Data Processing

CMJ data collected using the Infini-T P6000 force platform (BTS Bioengineering, Italy) were processed with the device's proprietary software. Data collected with the WBB (Nintendo®, Japan) were processed using a custom Python routine, in which raw data

were opened, visualized, and used to calculate jump height through the flight-time estimation method^{19,20}. After processing, the results were tabulated and stored in a Microsoft Excel spreadsheet. All researchers involved in data collection and processing were previously trained to handle the devices for which they were responsible.

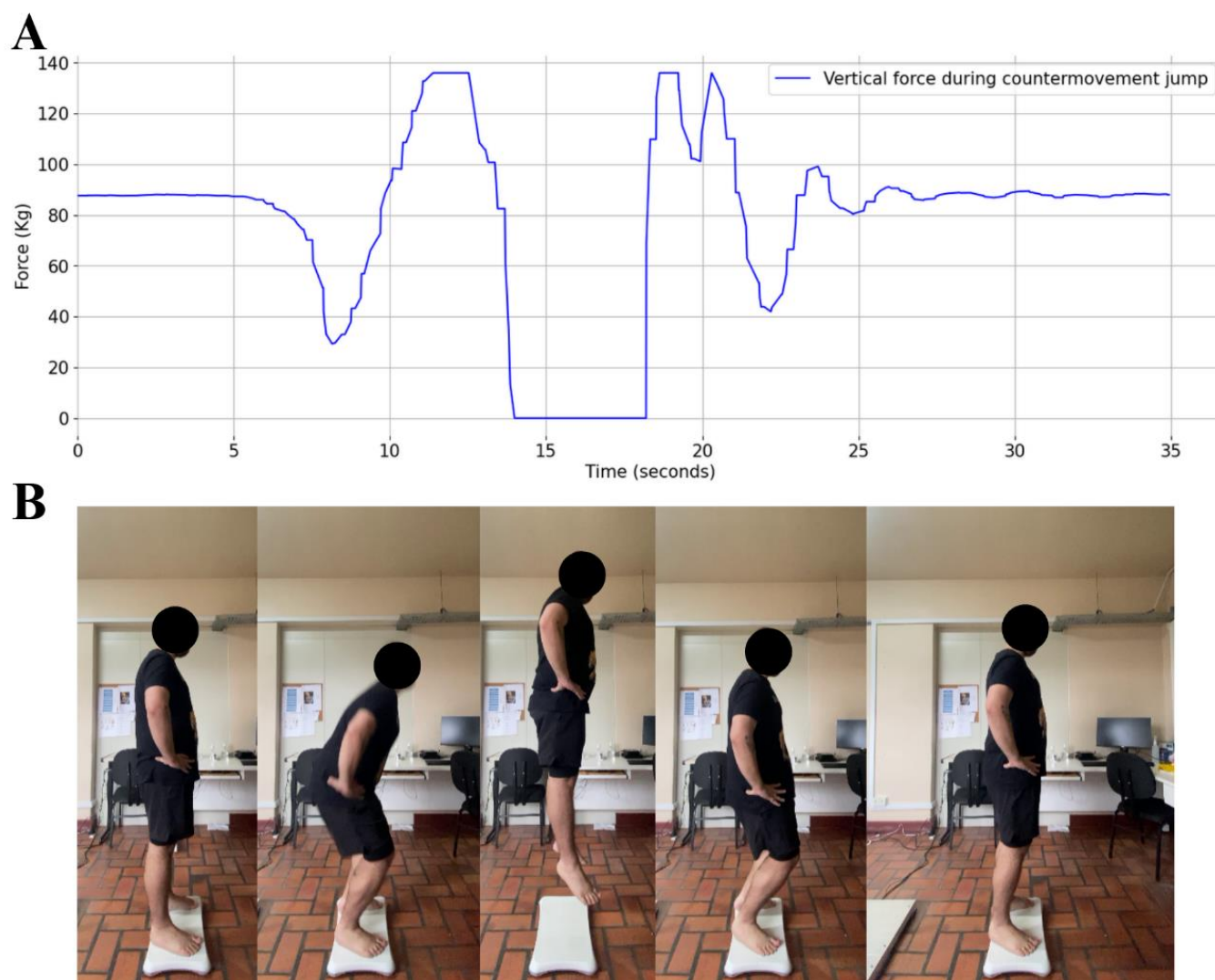


Figure 1. Counter movement jump on the Wii™ Balance Board (Nintendo®, Japan). Legend: A – Vertical force signal during execution of the counter movement jump on the Wii™ Balance Board platform (Nintendo®, Japan). B – Execution of the counter movement jump on the Wii™ Balance Board platform (Nintendo®, Japan).

Statistical Analysis

All statistical analyses were performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA), except for the Bland–Altman analysis, which was conducted using Jamovi version 2.3.28 (The Jamovi Project, Sydney, Australia). The significance level was set at $p < 0.05$.

The two-way mixed-effects ICC (3,1) was used to assess both consistency and absolute agreement, considering a single rater and a single measurement and with 95% confidence intervals²¹. Systematic differences between methods were assessed during the ICC analysis using the repeated-measures ANOVA (between-items) test embedded within the ICC procedure, while normality was examined through distribution plots to verify the robustness of the analysis under the ICC assumptions. The standard error of measurement (SEM) was estimated from the square root of the residual error of the ANOVA, and the minimum detectable change at 95% confidence (MDC95) was calculated using the formula:

$$MDC_{95} = SEM \times 1.96 \times \sqrt{2}$$

The Bland–Altman analysis was applied to quantify the mean bias between methods and to assess the limits of agreement,

while Cronbach's alpha (α) was used as a complementary measure to verify the consistency among the different methods.

RESULTS

A total of 79 participants were assessed, comprising 55 women (69.6%) and 24 men (30.4%), with a mean age of 30.8 ± 10.74 years and a mean body mass index (BMI) of 24.4 ± 4.17 kg/m². Sample characterization variables, as well as jump height values obtained in the countermovement jump using the Infini-T P6000 force platform (BTS Bioengineering, Italy) and the WBB (Nintendo®, Japan), are presented in Table 1.

Table 1. Sample characterization variables and jump height during the Countermovement Jump.

	Total Group (n=79) $\bar{x}$ (SD)	Women (n=55) $\bar{x}$ (SD)	Men (n=24) $\bar{x}$ (SD)
Characterization Variables			
Age (years)	30.81 (± 10.74)	30.41 (± 10.66)	31.70 (± 10.97)
Height (cm)	167.21 (± 8.37)	163.29 (± 5.90)	176.20 (± 5.87)
Mass (kg)	68.74 (± 14.93)	63.55 (± 11.37)	80.65 (± 15.40)
BMI (kg/m ²)	24.43 (± 4.17)	23.80 (± 3.79)	25.88 (± 4.67)
Muscle Mass (kg)	28.09 (± 7.22)	24.22 (± 3.20)	37.98 (± 5.89)
Body Fat (%)	26.05 (± 9.17)	29.40 (± 7.13)	18.38 (± 8.74)
Jump Height (cm) in Countermovement Jump			
Infini-T P6000	15.98 (± 5.72)	13.43 (± 3.76)	21.84 (± 5.13)
Wii™ Balance Board	16.90 (± 5.45)	14.64 (± 4.14)	22.08 (± 4.54)

Legend: $\bar{x}$ – Mean; SD – Standard deviation; cm – Centimeters; kg – Kilograms.

A total of 79 valid jump height measurements were analyzed using the Infini-T P6000 force platform (BTS Bioengineering, Italy) and the WBB (Nintendo®, Japan). Cronbach's alpha coefficient ($\alpha = 0.923$) indicated excellent internal consistency between the measurements. The repeated-measures ANOVA performed during the ICC test revealed significant systematic differences between the methods [$F(1,78) = 7.514$; $p = 0.008$], indicating that the 0.92 cm difference between the means was statistically significant.

The ICC values were high for both consistency (ICC = 0.857; 95% CI = 0.786–0.906) and absolute agreement (ICC = 0.848; 95% CI = 0.762–0.902), with all coefficients statistically significant ($p < 0.001$). The standard error of measurement (SEM) was 0.86, resulting in an MDC95 ≈ 2.38 . Bland–Altman analysis indicated a bias of -0.92 (95% CI: -1.59 to -0.25), consistent with the ANOVA findings. Table 2 presents the values of the Bland Altman test, while Figure 2 presents the Bland-Altman plots.

Table 2. Values of the Bland Altman test.

	Estimate	95% Confidence Interval	
		Lower	Upper
Bias (n = 79)	-0.92	-1.59	-0.25
Lower limit of agreement	-6.77	-7.92	-5.62
Upper limit of agreement	4.93	3.78	6.08

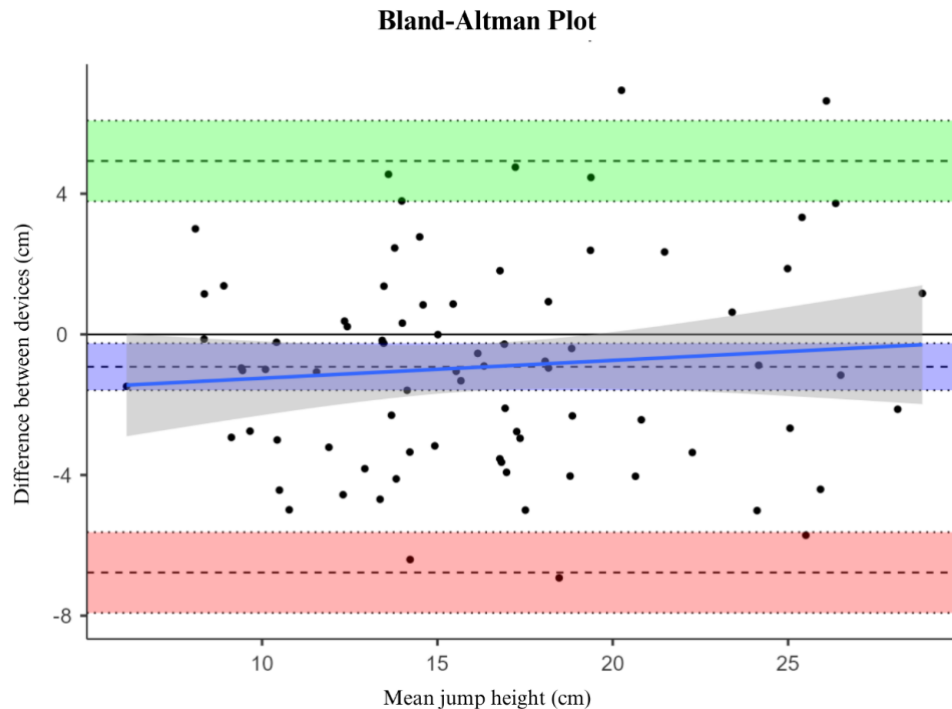


Figure 2. Bland–Altman plots for agreement between the Infini-T P6000 force platform (BTS Bioengineering, Italy) and the Wii™ Balance Board (Nintendo®, Japan).

DISCUSSION

The present study investigated the reliability and agreement of jump height measurements in the countermovement jump (CMJ) obtained using the Infini-T P6000 force platform (BTS Bioengineering, Italy) and the WBB (Nintendo®, Japan). The results demonstrated high reliability between the methods, although the presence of systematic error must be considered in both practical applications and scientific interpretation.

Overall reliability was classified as excellent, as indicated by Cronbach's alpha coefficient ($\alpha = 0.923$) and high ICC values for both the consistency model (ICC = 0.857; 95% CI = 0.786–0.906) and absolute agreement model (ICC = 0.848; 95% CI = 0.762–0.902). These values exceed the 0.75 threshold generally considered indicative of good reliability in physical performance studies^{22–24} and approach or surpass 0.90, the level recommended for clinical and individual applications^{21,25–27}. Thus, both instruments adequately preserve participant ranking and demonstrate consistent variability^{23,24}.

However, both repeated-measures ANOVA and Bland–Altman analysis revealed a mean bias of 0.92 cm, with the WBB (Nintendo®, Japan) systematically overestimating jump height compared to the Infini-T P6000. These findings highlight that, although measurements are highly reliable and vary jointly, the methods are not directly interchangeable. Such systematic bias is relevant in performance monitoring contexts, as substituting the equipment could produce apparent gains of approximately one centimeter that do not reflect true improvements in jump ability.

Individual measurement precision was also assessed: the standard error of measurement (SEM = 0.86) and the minimum detectable change at 95% confidence (MDC95 = 2.38) indicate that changes smaller than approximately 2.4 cm may reflect inherent measurement variability rather than true performance changes. Consequently, the mean 0.92 cm difference between methods, although systematic, falls below the MDC95, suggesting limited impact in group analyses but potential for misinterpretation in direct comparisons or clinical/individual decision-making.

Still regarding the bias observed in the Bland–Altman analysis, Figure 2 shows that the bias line is slightly tilted, indicating that jump height may minimize or amplify this mean bias. Although the mean difference between methods was below the MDC95 (~2.4 cm), indicating good agreement at the group level, this difference remains within the measurement error margin, suggesting limited interchangeability for individual assessments.

From a practical standpoint, longitudinal monitoring should always be performed using the same instrument to avoid artificial bias. When comparisons between platforms are unavoidable, applying an offset correction may help align values and reduce discrepancies, although individual error remains within the SEM and MDC95 range. Additionally, reporting reliability (α and ICC), precision (SEM, MDC95), and agreement (Bland–Altman) together provide a comprehensive assessment of measurement quality, as recommended in the literature on sports performance assessment^{21–23,27}.

Regarding methodological aspects related to safety during data collection, no significant adverse events occurred during CMJ testing. However, the evaluator's close presence was essential to ensure safety during WBB (Nintendo®, Japan) testing. Due to the WBB's reduced dimensions, some participants experienced balance disturbances upon landing, or they landed near the platform edges. Immediate intervention by the evaluator was necessary in these cases to prevent falls or injuries, leading to trial cancellation and repeated attempts. Therefore, the use of the WBB (Nintendo®, Japan) for CMJ assessment is limited when support for participants is unavailable or in populations at high risk of falls.

Furthermore, the present study findings, consistent with previous research, demonstrate the WBB (Nintendo®, Japan) applicability as a device capable of providing reliable and precise measurements^{7,13–16}. Most studies on WBB (Nintendo®, Japan) use have focused on balance assessment, likely due to data collection software such as BrainBlox¹⁸ and WBB (Nintendo®, Japan) Sway Program^{11,12}, which provide COP and postural sway measures.

Compression force measurements using the WBB (Nintendo®, Japan) have also shown relevant reliability metrics. Blomkvist et al. (2016)¹⁵ reported very high to excellent agreement in peak handgrip force in older adults compared to the JAMAR hydraulic hand dynamometer (Sammons Preston Jamar, USA). Jorgensen et al. (2015)¹⁶ reported very high to excellent agreement in lower-limb isometric peak force relative to the Stationary Isometric Dynamometer (Newtest, Finland). These findings, together with the present results, indicate the feasibility of using the WBB as an alternative tool for obtaining simpler biomechanical variables, such as CMJ jump height.

In summary, the WBB (Nintendo®, Japan) demonstrates high reliability for measuring CMJ jump height but tends to overestimate values relative to the Infini-T P6000. Its use is valid in monitoring contexts if the same device is consistently used and individual decisions are based on changes exceeding the MDC95 (~2.4 cm). In comparative studies, the systematic bias of ~0.92 cm should be considered to ensure accurate interpretation of results.

Limitations of the study

The findings of the present study are limited to the measurement of the countermovement jump in healthy adults and cannot be generalized to other age groups, such as children and older adults, to specific health conditions, or to other types of jumps. The validity of the Wii™ Balance Board (Nintendo®, Japan) for assessing countermovement jump performance in other age groups and under specific conditions should be investigated to broaden the applicability of this device or to identify its limitations.

Although the average of two to three repetitions is commonly used for validating power tests, the present study used a single valid measurement, allowing one to three familiarization trials and as many attempts as needed to obtain a valid measure. This procedure was chosen to avoid participant fatigue during testing; however, for future studies, the use of the average across multiple trials is recommended. Additionally, future research should include test–retest and inter-rater validation measures.

CONCLUSION

The findings of this study indicate that the Wii™ Balance Board (Nintendo®, Japan) is a highly reliable instrument for measuring countermovement jump height, exhibiting a small systematic bias of +0.92 cm compared to a conventional force platform. In monitoring contexts, the MDC95 of approximately 2.4 cm should be considered. As comparative studies, an offset of ~0.92 cm is recommended to account for the systematic bias of the Wii™ Balance Board (Nintendo®, Japan).

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