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Reliability and Validity of Pressure Sensor-Embedded Socks for Measuring Countermovement Jump Performance

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Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.199

Assessing athletic performance through vertical jump metrics, such as jump height (JH) and reactive strength index (RSI), is common in sports performance and rehabilitation settings. Traditionally, force plates have been the gold standard for these measurements, but wearable technology offers potentially more accessible alternatives. This study aimed to evaluate the reliability and validity of pressure sensor-embedded socks, compared with force plates, for measuring contact time, flight time, JH, RSI, and modified RSI (mRSI) during countermovement jumps (CMJ). Twenty active individuals performed CMJs while wearing the socks, and force plate data were simultaneously collected. The results indicated that the force plates showed generally acceptable reliability, while the socks showed questionable reliability. Regarding validity, the socks appeared similar to the force plate data, but this should be interpreted with caution given the lower reliability metrics observed in the socks. Thus, the present study suggests that while sensor socks show promise for field-based assessments, improvements in sensor technology and data processing, such as higher sampling rates, are needed to improve reliability. These findings indicate that wearable technology, such as sensor-embedded socks, can serve as a viable alternative for data measurement in sports science when traditional force plates are not accessible. However, while these socks appear valid compared to force plates, their performance may not always be consistent or reliable.

Keywords: sensors, wearable technology, reliability, validity, jump

Assessing athletic performance in strength and conditioning and sport science relies heavily on precise, reliable measurement tools (Lutz et al., 2019). One of the most commonly used tests to assess athletic performance in these settings is the countermovement jump (CMJ) (Gathercole et al., 2015). Traditionally, force plates have served as the gold standard for measuring jump metrics like jump height (JH) and reactive strength index (RSI) during the CMJ (Markovic et al., 2004). However, wearable technology offers a potentially more versatile and accessible option for performance monitoring (Seshadri et al., 2019). While wearable technology may never replace gold-standard assessments such as force plates, these devices add practicality to field-based testing and may be more cost-effective in certain settings.

Previous research has examined the reliability and validity of various wearable technologies for assessing athletic performance, particularly in vertical jump tests. Camuncoli et al. (2022) reported high reliability and validity in assessing double-leg and single-leg CMJ performance using an inertial measurement unit, highlighting wearable devices' potential to replicate or even extend the capabilities of traditional force plates in certain contexts. Similarly, Loukovitis et al. (2021) assessed the test-retest reliability of insole pressure sensors and inertial measurement units across various movement patterns and reported good reliability. These studies underscore the evolving landscape of performance monitoring, where wearable technologies not only complement but, in some instances, enhance the data collection processes in both laboratory and field settings. However, with the recent advent of pressure-sensor socks, we are unaware of any prior studies examining their validity and reliability, though Luczak et al. (2019) have suggested they may be used during other athletic activities. Specifically, Luczak et al. (2019) examined three specific movements, including squats, shifting pressure from one foot to the other, and shifting pressure from the toes to the heels, and reported that pressure socks seem sensitive enough to

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detect these changes in pressure. In sports performance settings, the convenience and immediacy of wearable data could significantly enhance coaching strategies and athlete monitoring (Li et al., 2016; Luczak et al., 2023), helping optimize performance and mitigate injuries by ensuring athletes do not return to play prematurely. Thus, wearable sensors can provide accurate, real-time feedback for performance monitoring (Camuncoli et al., 2022; Li et al., 2016; Loukovitis et al., 2021; Luczak et al., 2019; Zhang & Wang, 2024), particularly when gold-standard assessments are unavailable or not feasible. Thus, further examination of these devices in commonly assessed athletic movements, such as the CMJ, is needed to better understand their efficacy.

To assess the potential of these devices for the CMJ, it is important to establish their reliability and validity. Common assessments of test-retest reliability include the intraclass correlation coefficient (ICC), standard error of measurement (SEM), and coefficient of variation (CV) (Hopkins, 2000). Reliability evaluations also benefit from quantifying the minimum detectable change (MDC), the smallest worthwhile change that can be considered real with 95% confidence (Weir, 2005). By combining these assessments with common validity measures, including Bland-Altman plots, correlations, and dependent t-tests to assess criterion-referenced validity, researchers can obtain a holistic picture of the efficacy of these wearable devices. Therefore, this study aims to assess the reliability and validity of pressure sensor-embedded socks for measuring CMJ performance compared with gold-standard force plates. This study builds on this foundation by examining the specific capabilities of pressure sensor-embedded socks to measure JH and RSI, as well as contact and flight times, which are used to calculate JH and RSI, since these are common metrics for assessing CMJ performance. This comparison aims to determine how reliably these innovative wearable sensors can be used in both sports performance enhancement and rehabilitation protocols.

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Data will be made available upon reasonable request.

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Methods

Research Design

This study examined the reliability and validity of pressure sensor-embedded socks (Sensoria Health Inc., Richmond, WA) compared with the gold-standard force plates (Kistler Group, Winterthur, Switzerland) for measuring JH and RSI, as well as contact and flight times, during the CMJ. Participants visited the data collection site twice. During each visit, participants performed CMJs on force plates while wearing the socks.

Participants

An a priori power analysis (power = 0.80; alpha = 0.05) determined that $n = 19$ participants were needed. Twenty healthy, recreationally active males and females ($n = 11$ males, $n = 9$ females; mean ± standard deviation, age 21.42 ± 1.51 years, height 167.64 ± 6.26 cm, weight 73.98 ± 20.31 kg), defined as exercising at least 2–3 times per week based on self-report, participated in the study. Before data collection, all participants provided informed consent, completed the PAR-Q+, and were allowed to participate if they answered “no” to questions 1–7 or “no” to all follow-up questions. This study was approved by the University’s Institutional Review Board (IRB-23-264).

Procedures

Upon arriving at the lab, participants had their height and weight measured, then completed a standardized warm-up before performing the CMJ. The warm-up consisted of walking on a treadmill (iFIT, NordicTrack, Logan, UT) for 5 minutes at 2.5 mph, followed by dynamic stretching, including 5 forward lunges per leg, 5 walking hamstring stretches per leg, 5 bodyweight squats, and 5 rebound hops. Then, participants donned the socks on each foot (Sensoria Health Inc., Richmond, WA). The sock sizes were as follows: medium, fitting U.S. men’s shoe sizes 7–9 or women’s sizes 8–10; large, fitting men’s sizes 9–11 or women’s sizes 10–12; and extra large, fitting men’s sizes 11–13 or women’s sizes 12–14, ensuring proper fit for optimal sensor performance. We calibrated force plates before each testing session to ensure accuracy. Participants rested for at least 60 seconds between jumps. We set standards to ensure consistency between visits, with at least 48 hours between each participant’s

Section: Student-Led Research • doi.org/10.56980/jkw.v1511.199

two visits. Next, participants completed the CMJ while standing on force plates (Kistler Group, Winterthur, Switzerland) (one force plate per foot). To perform the CMJ, participants completed a countermovement of self-selected depth, followed by a maximal vertical jump. Participants completed three CMJ trials and kept their hands on their hips throughout each trial.

Data Analysis

During all vertical jumps, the raw z-axis ground reaction forces (GRFs) from the force plates were sampled at 1 kHz using the Motion-Monitor (Innovative Sports Training, Inc., Chicago, IL, USA). We summed data from both force plates before subsequent analysis. Raw pressure sensor data from the socks were collected at 50 Hz, which is the default sampling rate for the socks, at the three pressure sensors on the sock (one underneath the calcaneus, one underneath the medial metatarsal, and one underneath the lateral metatarsal) using the manufacturer's software (Sensoria Workbench Android application) and were summed prior to subsequent analysis. Specifically, for the socks, we summed the data from the three sensors on one foot independently of the other foot. After this, the signals from each foot were summed. We stored all signals on a computer and processed them offline with custom-written software (LabVIEW v. 2024, National Instruments, Austin, TX, USA). We time-aligned the force plate and sock data for the following analyses. For all CMJs, the investigator identified the point at which the signal decreased 5 standard deviations below baseline (a – unweighting), the point at which the feet left the force plates when the force signal reached zero (b – takeoff), and the point at which the feet contacted the force plates after the jump with a positive deflection in the force signal (c – landing) (Figure 1). We determined these same points from the pressure sensor data in the socks. Metrics taken from the GRFs and socks included contact time (time from unweighting to takeoff), flight time (time from takeoff to landing), jump height (see equation below for calculation from the flight-time method), reactive strength index (RSI, flight time divided by contact time), and modified RSI (mRSI, jump height divided by contact time).

$$\text{Jump Height} = \frac{9.80665 \times \text{Flight Time}^2}{8}$$

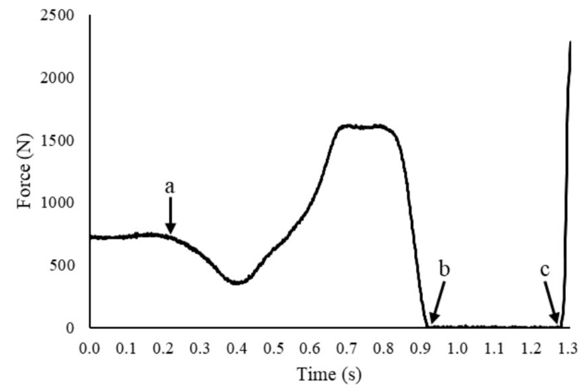

Figure 1: An example force-time tracing for the countermovement jump where (a) is the point at which the force signal decreased 5 standard deviations below baseline, (b) is the point at which the feet left the force plates, and (c) is the point at which the feet contacted the force plates after the jump.

Statistical Analyses

We performed all statistical analyses in R, with an a priori alpha of 0.05.

Reliability

To compare reliability between data collected from the force plates and socks, we used separate one-way repeated-measures ANOVAs (Visit 1 vs. Visit 2) to calculate test-retest reliability for contact time, flight time, jump height, RSI, and mRSI from the force plates and socks (Weir, 2005). The ICC used model "2,1" (Shrout & Fleiss, 1979; Weir, 2005):

$$ICC_{2,1} = \frac{MS_S - MS_E}{MS_S + (k-1)MS_E + \frac{k(MS_T - MS_E)}{n}}$$

Where MS_S is the mean square of the dependent variable, MS_E is the mean square error, MS_T is the mean square total, k is the number of trials ($k = 2$), and n is the sample size. We used the ICCs from model "2,1" to generalize to other testers and laboratories (Weir, 2005). We calculated the 95% CI for each $ICC_{2,1}$ (Shrout & Fleiss, 1979) to test whether each $ICC_{2,1}$ was significantly different from zero (Vincent & Weir, 2020). The SEM, CV, and MDC were calculated using equations previously described (Weir, 2005):

$$SEM = \sqrt{MS_E}$$

$$CV = \frac{SEM}{\text{grand mean}} \times 100$$

$$MDC = SEM \times 1.96 \times \sqrt{2}$$

The grand mean was calculated as the pooled mean across all subjects and visits.

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Validity

To examine the validity of the socks to assess contact time, flight time, jump height, RSI, and mRSI compared to force plates, Bland-Altman plots with 95% limits of agreement were performed, as well as dependent-samples t-tests to compare all data between the socks and force plates, and Pearson product-moment correlation coefficients to examine the relationship between data derived from the socks versus force plates (Bland & Altman, 1986). We evaluated the strength of association based on the absolute values of the correlation coefficients: 0.90–1.00 = very high, 0.70–0.89 = high, 0.50–0.69 = moderate, 0.30–0.49 = low, and 0.00–0.29 = negligible.

Results

Reliability

Table 1 shows ICCs, SEMs, CVs, and MDCs for all metrics. Contact time from the force plates exhibited an ICC = 0.468 and CV = 19.24%, flight time from the force plates exhibited an ICC = 0.949 and CV = 3.97%, jump height from the force plates exhibited an ICC = 0.951 and CV = 7.89%, RSI from the force plates exhibited an ICC = 0.575 and CV = 13.41%, and mRSI from the force plates exhibited an ICC = 0.842 and CV = 13.23%. Contact time from the socks exhibited an ICC = 0.122 and CV = 43.64%; flight time from the socks exhibited an ICC = 0.455 and CV = 30.50%; jump height from the socks exhibited an ICC = 0.448 and CV = 68.85%; RSI exhibited an ICC = 0.165 and CV = 31.74%; and mRSI exhibited an ICC = 0.607 and CV = 35.65%.

Validity

Figures 2–6 show the Bland-Altman plots. Overall, data from the force plates and socks fell within the 95% limits of agreement. One case was outside the limits for contact time, jump height, and RSI, while two cases were outside the limits for mRSI. The results of the dependent-samples t-test indicated no significant differences between the force plates and socks across any metric ($p \geq 0.121$). The correlation analysis showed a moderate relationship between flight time, jump height, and RSI from the force plates and socks ($r \geq 0.600$, $p \leq 0.005$), and a strong relationship between mRSI from the force plates and socks ($r = 0.738$, $p < 0.001$). Contact time showed a negligible relationship between the force plates and socks ($r = 0.259$, $p = 0.270$).

Discussion

This study evaluated the reliability and validity of pressure sensor-embedded socks compared with gold-

Figure 2: Bland-Altman plots comparing force plates to socks for jump height.

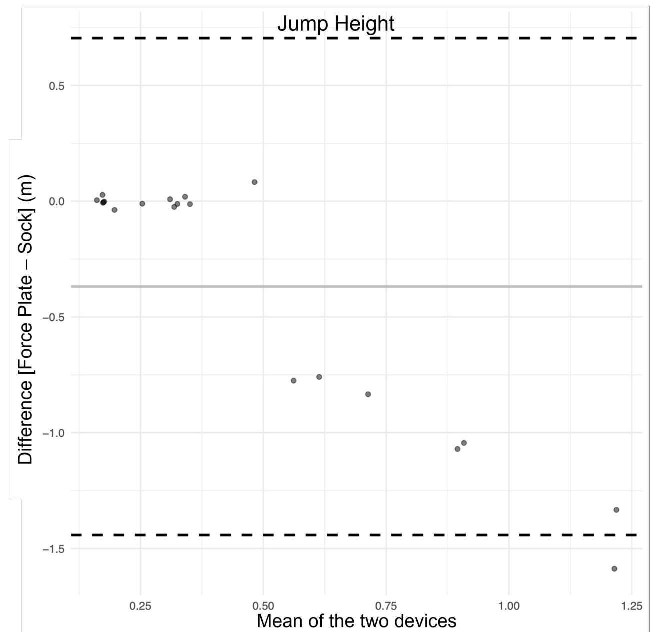
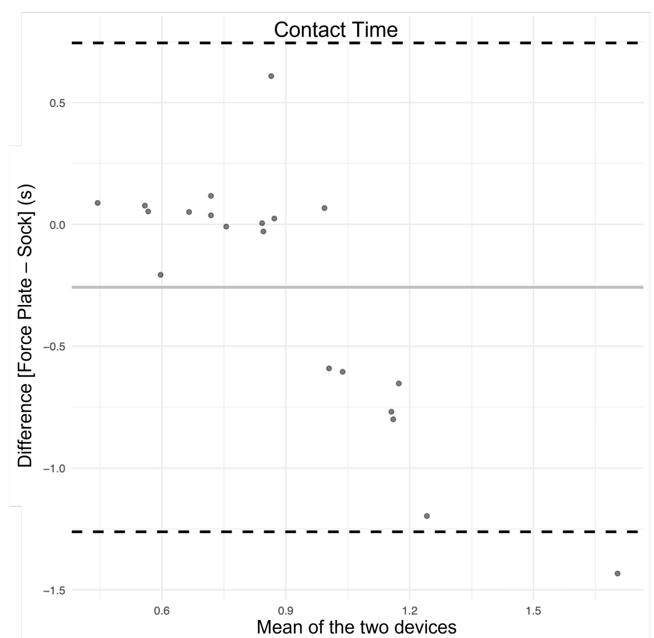


Figure 3: Bland-Altman plots comparing force plates to socks for contact time.



Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.199

Table 1: *Means, standard deviations (SDs), intraclass correlation coefficients (ICCs), coefficients of variation (CVs), standard errors of measurement (SEMs), and minimal detectable changes (MDCs) for all calculated metrics.*

Metric	Mean	SD	ICC	CV	SEM	MDC
Force Plate Contact Time (s)	0.767	0.170	0.468	19.235	0.149	0.413
Force Plate Flight Time (s)	0.480	0.095	0.949	3.971	0.019	0.054
Force Plate Jump Height (m)	0.294	0.117	0.951	7.889	0.024	0.066
Force Plate RSI	0.642	0.123	0.575	13.413	0.087	0.242
Force Plate mRSI	0.384	0.129	0.842	13.226	0.052	0.144
Sock Contact Time (s)	1.025	0.529	0.122	43.635	0.390	1.082
Sock Flight Time (s)	0.668	0.315	0.455	30.503	0.179	0.496
Sock Jump Height (m)	0.662	0.610	0.448	68.848	0.351	0.972
Sock RSI	0.676	0.139	0.165	31.740	0.178	0.493
Sock mRSI	0.561	0.335	0.607	35.649	0.179	0.496

Note. SD = standard deviation; ICC = intraclass correlation coefficient; CV = coefficient of variation (%); SEM = standard error of measurement; MDC = minimal detectable change; RSI = reactive strength index; mRSI = modified reactive strength index.

Figure 4: Bland-Altman plots comparing force plates to socks for flight time.

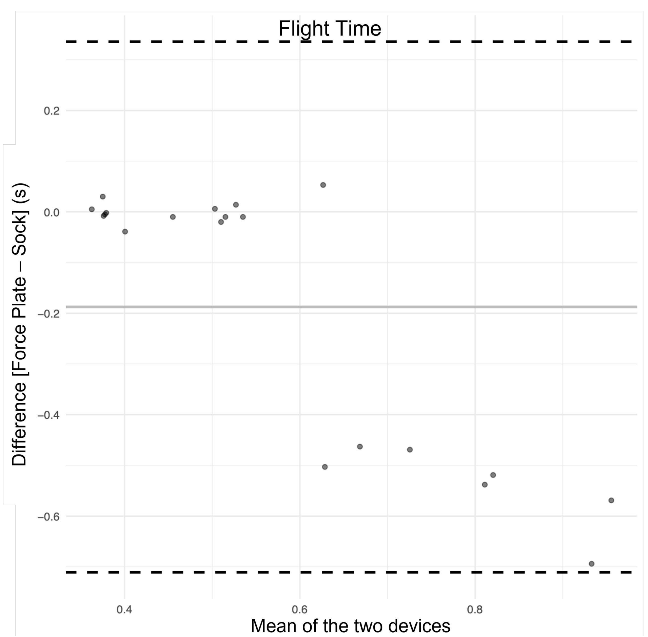
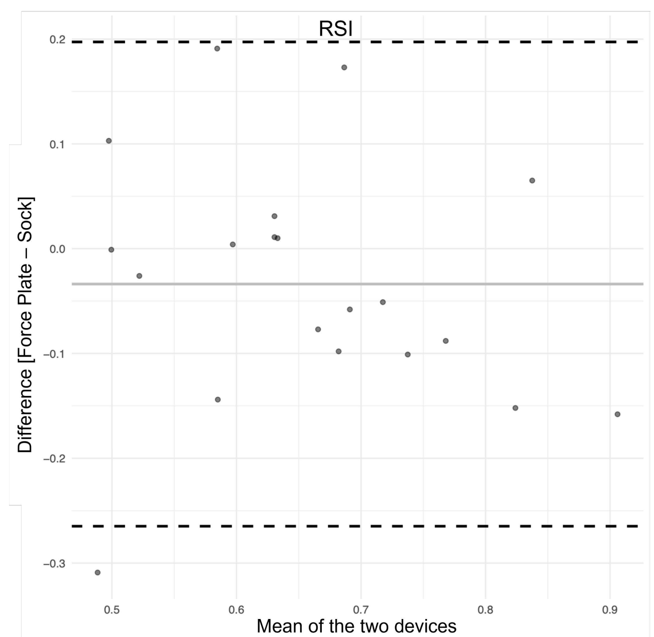


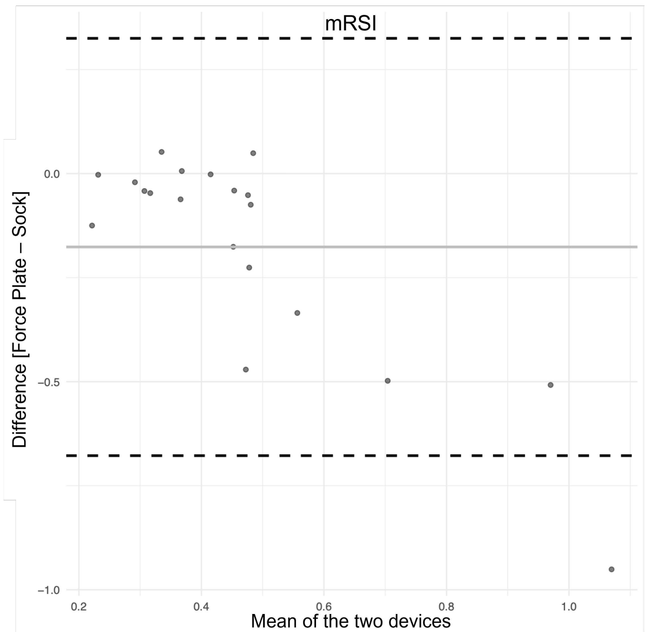
Figure 5: Bland-Altman plots comparing force plates to socks for reactive strength index (RSI).



standard force plates for measuring JH, RSI, contact time, and flight time during CMJ. Overall, our findings show that reliability for the socks should be interpreted with caution because of the lower ICCs and higher CVs (ICCs $\leq$ 0.607, CVs $\geq$ 30.50%). However, further research is needed to better understand the usefulness of these devices. Despite their questionable reliability, the socks used in the present study may show some agreement with JH and RSI compared with gold-standard force plates. Nonetheless, these results should be interpreted with caution due to the large variability and lower reliability metrics in the socks. These results, at the very least, provide a proof-of-concept approach for future research to build on. With the advent of this technology, it is prudent to gather more information on the effectiveness of these socks for potential assessments of JH and RSI.

Previously, Camuncoli et al. (2022) examined the reliability of an inertial measurement unit for assessing vertical jump performance and reported excellent reliability for double-leg CMJs (ICC = 0.92) and single-leg CMJs (ICC = 0.89). Similarly, Picerno et al. (2011)

Figure 6: Bland-Altman plots comparing force plates to socks for modified reactive strength index (mRSI).



examined an inertial measurement unit for assessing CMJ performance, suggesting that these devices may provide reliable data compared with force plates; furthermore, Loukovitis et al. (2021) assessed the test-retest reliability of PODOSmart, which uses insole pressure sensors, and found good-to-excellent reliability, with ICC values ranging from 0.802 to 0.997. Although we are not aware of any studies reporting reliability metrics for pressure sensor-embedded socks used to assess vertical jumps, previous research suggests that these devices may provide reliable data during movements such as walking and squatting (Daugulis et al., 2023; DeBerardinis et al., 2020). In the present study, the force plates consistently showed generally acceptable reliability across all metrics, with ICCs ranging from 0.468 to 0.951 and CVs between 3.97% and 19.24%, which aligns with previous research examining the reliability of force plates in athletic performance testing (Bohannon et al., 2020; Gillen et al., 2018; Lambrich et al., 2023).

Nevertheless, the lower ICCs and higher CVs suggest some variability between visits. Although the present study included recreationally active individuals, this may still reflect a learning effect, even with gold-standard force plates. In contrast, the socks' reliability is more questionable, with ICCs ranging from 0.122 to 0.607 and CVs ranging from 30.50 to 68.85%. The lower reliability may be attributed to the lower sampling frequency of the socks (50 Hz) compared to the force plates (1 kHz) and the intrinsic properties of the pressure sensors used. The socks used in the present study can be sampled at 100 Hz per manufacturer specifications, which should be considered in future studies, as this would increase data resolution.

Furthermore, jump height and RSI were calculated from flight time, so flight time results directly affected subsequent calculations. Despite these limitations, the socks' reliability for mRSI (ICC = 0.607, CV = 35.65%), a commonly assessed performance metric for CMJs, suggests they may still be useful in specific applications where high precision is less critical. Thus, although the present study showed less-than-optimal reliability for metrics calculated from the socks compared with the force plates, devices like these are still worth considering in field-based settings, particularly when access to force plates or jump mats is unavailable. However, we suggest interpreting these results with caution, as they appear to require further research to better determine their usefulness. Furthermore, coaches and practitioners, as well as future researchers, should consider increasing the sampling rate to improve data resolution and potentially the devices' reliability. Notably, the metric with the highest reliability for the socks did not use flight time in its calculation. Thus, future studies should give greater consideration to calculating flight time.

In general, although the socks' reliability metrics are questionable, the data agree with the force plate data when examining Bland-Altman plots, dependent-samples t-tests, and correlation analyses. Specifically, the Bland-Altman plots showed that only one case was outside the limits of agreement for contact time, jump height, and RSI, and only two cases were outside the limits of agreement for mRSI. Furthermore, the lack of significant differences in dependent-samples t-tests and the moderate-to-high correlation coefficients support agreement between the socks and the force plates. However, the large variability still calls into question the overall validity of the socks compared to the force plates. Despite agreement in these tests, the questionable reliability may lead to greater variability in data derived from the socks, necessitating further research as these technologies advance. In a systematic review and meta-analysis, Kobsar et al. (2020) examined the reliability and validity of inertial measurement units for assessing walking biomechanics, suggesting that these devices may provide valid, more practical methods for assessing movement patterns during walking. Although different from the CMJs in the present study, Kobsar et al. (2020) highlight the need for more practical biomechanical assessments, which is particularly important with the advent of sports science. For jumping, Buckthorpe et al. (2012) suggested that pressure sensor mats, similar to the socks used in the present study, may provide valid measures of vertical

Section: Student-Led Research • doi.org/10.56980/jkw.v1511.199

jump height compared to force plates.

Additionally, Martínez-Martí et al. (2016) similarly examined instrumented insoles for measuring jump height during the vertical jump, demonstrating a high correlation between the insoles and the laser platform and a high-speed motion capture system. Although further research is warranted on the devices used in the present study, these data provide a basis for future researchers to continue expanding practical methods for assessing CMJ performance beyond gold-standard lab assessments.

In conclusion, the present study suggests that the overall reliability of pressure sensor-embedded socks is questionable. However, they may provide data similar to that of force plates, with continued research into their efficacy. We recommend viewing the present study as a proof-of-concept approach, with future research needed to build on the present findings. One limitation of the present study is the sampling rate of the pressure sensor-embedded socks, which was 50 Hz, compared with the force plates' 1 kHz sampling rate. The present study used the 50 Hz sampling rate, as it is the default, and many practitioners may use default settings when using newer technology. We recommend further studies at higher sampling rates, which may yield more reliable metrics (Hughes et al., 2024).

Furthermore, much of the previous research cited in the present study examined walking or squatting using pressure sensors, rather than faster, higher-impact movements such as the CMJ. These devices may not be well suited to such movements. Additionally, the present study had a sample size of $n = 20$ and used a proof-of-concept approach. Although the study was statistically powered based on a priori analyses, future studies should consider larger sample sizes and examine these devices in various populations. Another note for future consideration: several metrics (flight time, jump height, RSI) were derived from flight time. Thus, the flight-time results affected these subsequent calculations. Although this study did not directly assess force production, future studies should consider alternative methods for calculating metrics such as jump height to better understand how to derive these data from pressure sensor-embedded socks. One final limitation: summing signals from individual pressure sensors may have affected results because pressure points on the feet change across the different phases of the jump. Future studies could examine how pressure changes on these sensors across the different phases. While these devices cannot fully replace force plates, the socks provide a valuable option for field-based testing, which is important to consider given the growth of sports science and the use of technology in strength and conditioning settings. Future improvements in sensor technology and data-processing algorithms, along with higher sampling rates and the use of IMU sensors in socks, could improve accuracy and reliability, making wearable technology an increasingly viable option for sports performance assessment.

Conclusion

As sports science grows and more strength and conditioning professionals use technology to monitor athletic performance, it is important to examine field-based testing options in practical settings. The convenience and portability of the socks used in the present study make them attractive to coaches and sports scientists who need to conduct performance testing in various settings, such as on the field or in less-equipped facilities. The socks used in the present study may offer a practical, convenient alternative for monitoring changes in CMJ performance or other athletic performance variables. However, further research is needed examining these socks during dynamic movement to increase confidence in the data.

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Section: Student-Led Research • doi.org/10.56980/jkw.v15i1.199

Section: Student-Led Research • doi.org/10.56980/jkw.v1511.199

References

Bland, J. M., & Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*, *1*(8476), 307–310.

Bohannon, N. A., Gillen, Z. M., Shoemaker, M. E., McKay, B. D., Gibson, S. M., & Cramer, J. T. (2020). Test-retest reliability of static and countermovement power push-up tests in young male athletes. *Journal of Strength and Conditioning Research*, *34*(9), 2456–2464. https://doi.org/10.1519/JSC.0000000000003684

Buckthorpe, M., Morris, J., & Folland, J. P. (2012). Validity of vertical jump measurement devices. *Journal of Sports Sciences*, *30*(1), 63–69. https://doi.org/10.1080/02640414.2011.624539

Camuncoli, F., Barni, L., Nutarelli, S., Rocchi, J. E., Barcillesi, M., Di Dio, I., Sambruni, A., & Galli, M. (2022). Validity of the baiobit inertial measurements unit for the assessment of vertical double- and single-leg countermovement jumps in athletes. *International Journal of Environmental Research and Public Health*, *19*(22), 14720. https://doi.org/10.3390/ijerph192214720

Daugulis, P., Katačevs, A., & Okss, A. (2023). Estimation of the knee joint load using plantar pressure data measured by smart socks: A feasibility study. *Technology and Health Care*, *31*(6), 2423–2434. https://doi.org/10.3233/THC-235008

DeBerardinis, J., Neilsen, C., Lidstone, D. E., Dufek, J. S., & Trabia, M. B. (2020). A comparison of two techniques for center of pressure measurements. *Journal of Rehabilitation and Assistive Technologies Engineering*, *7*, 2055668320921063. https://doi.org/10.1177/2055668320921063

Gathercole, R. J., Sporer, B. C., Stellingwerff, T., & Sleivert, G. G. (2015). Comparison of the capacity of different jump and sprint field tests to detect neuromuscular fatigue. *Journal of Strength and Conditioning Research*, *29*(9), 2522–2531. https://doi.org/10.1519/JSC.0000000000000912

Gillen, Z. M., Miramonti, A. A., McKay, B. D., Jenkins, N. D. M., Leutzinger, T. J., & Cramer, J. T. (2018). Reliability and sensitivity of the power push-up test for upper-body strength and power in 6-15-year-old male athletes. *Journal of Strength and Conditioning Research*, *32*(1), 83–96.

Hopkins, W. G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine*, *30*(1), 1–15.

Hughes, G. T. G., Camomilla, V., Vanwanseele, B., Harrison, A. J., Fong, D. T. P., & Bradshaw, E. J. (2024). Novel technology in sports biomechanics: Some words of caution. *Sports Biomechanics*, *23*(4), 393–401. https://doi.org/10.1080/14763141.2020.1869453

Kobsar, D., Charlton, J. M., Tse, C. T. F., Esculier, J.-F., Graffos, A., Krowchuk, N. M., Thatcher, D., & Hunt, M. A. (2020). Validity and reliability of wearable inertial sensors in healthy adult walking: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation*, *17*(1), 62. https://doi.org/10.1186/s12984-020-00685-3

Lambrich, J., Hagen, M., Schwiertz, G., & Muehlbauer, T. (2023). Concurrent validity and test-retest reliability of pressure-detecting insoles for static and dynamic movements in healthy young adults. *Sensors*, *23*(10), 4913. https://doi.org/10.3390/s23104913

Li, R. T., Kling, S. R., Salata, M. J., Cupp, S. A., Sheehan, J., & Voos, J. E. (2016). Wearable performance devices in sports medicine. *Sports Health*, *8*(1), 74–78. https://doi.org/10.1177/1941738115616917

Loukovitis, A., Ziagkas, E., Zekakos, D. X., Petrelis, A., & Grouios, G. (2021). Test-retest reliability of PODOSmart gait analysis insoles. *Sensors*, *21*(22), 7532. https://doi.org/10.3390/s21227532

Luczak, T., Burch, R. F., Smith, B. K., Carruth, D. W., Lamberth, J., Chander, H., Knight, A., Ball, J. E., & Prabhu, R. K. (2019). Closing the wearable gap-part v: Development of a pressure-sensitive sock utilizing soft sensors. *Sensors*, *20*(1), 208. https://doi.org/10.3390/s20010208

Luczak, T., Saucier, D., Chander, H., Tang, Y., Freeman, C., Lamberth, J., Ball, J. E., Grice, S. M., Middleton, C., Chen, C.-C., Jackson, K., Taquino, M., Parker, E., Gillen, Z. M., Neff, M., Duclos, M., Burch, R. F., Knight, A., & Tian, L. (2023). The opportunity to collect kinetic forces during a round of golf using wearable devices: Single-subject case study – the full swings. *2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 249–253. https://doi.org/10.1109/VRW58643.2023.00061

Lutz, J., Memmert, D., Raabe, D., Dornberger, R., & Donath, L. (2019). Wearables for integrative performance and tactic analyses: Opportunities, challenges, and future directions. *International Journal of Environmental Research and Public Health*, *17*(1), 59. https://doi.org/10.3390/ijerph17010059

Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *Journal of Strength and Conditioning Research*, *18*(3), 551–555. https://doi.org/10.1519/1533-4287(2004)18%

3C551:RAFVOS%3E2.0.CO;2

Martínez-Martí, F., González-Montesinos, J. L., Morales, D. P., Santos, J. R. F., Castro-Piñero, J., Carvajal, M. A., & Palma, A. J. (2016). Validation of instrumented insoles for measuring height in vertical jump. *International Journal of Sports Medicine*, *37*(5), 374–381. https://doi.org/10.1055/s-0035-1565137

Picerno, P., Camomilla, V., & Capranica, L. (2011). Countermovement jump performance assessment using a wearable 3D inertial measurement unit. *Journal of Sports Sciences*, *29*(2), 139–146. https://doi.org/10.1080/02640414.2010.523089

Seshadri, D. R., Li, R. T., Voos, J. E., Rowbottom, J. R., Alfes, C. M., Zorman, C. A., & Drummond, C. K. (2019). Wearable sensors for monitoring the internal and external workload of the athlete. *Npj Digital Medicine*, *2*, 71. https://doi.org/10.1038/s41746-019-0149-2

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, *86*(2), 420–428.

Vincent, W. J., & Weir, J. P. (2020). *Statistics in kinesiology* (5th ed.). Human Kinetics.

Weir, J. P. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *Journal of Strength and Conditioning Research*, *19*(1), 231–240.

Zhang, Z., & Wang, X. (2024). Wearable sports smart glasses real-time monitoring and feedback mechanism in physical education. *EAI Endorsed Transactions on Pervasive Health and Technology*, *10*. https://doi.org/10.4108/eetpht.10.5531

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