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VALIDITY OF A WIRELESS INERTIA MEASUREMENT DEVICE IN QUANTIFYING PERFORMANCE IN VERTICAL JUMPING TESTS

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INTRODUCTION: The use of technology in sport and fitness training has rapidly become a tool for both athletes and coaches in monitoring performance variables for optimizing training stimulus and recovery (Duking, Hotho, Holmberg, Fuss, & Sperlich, 2016; Peake, Kerr & Sullivan, 2018). Wireless fitness trackers, GPS and accelerometry devices are growing in popularity with the athletic population outside of the clinical setting due to their lower cost and ease of use compared to traditional clinical measurement tools (Dellaserra, Gao & Ransdell, 2014). With the increased popularity of these devices comes the necessity to understand and validate the information collected from them (Kooiman et al., 2015). Previous research has validated the measurement capability of wireless inertia sensors in the collection of curvilinear and linear velocity during upper body resistance exercise compared to 3D motion capture, which suggests it as a useful tool in a coaching environment (Sato, Beckham, Carroll, Bazyler, & Sha, 2015). Furthermore, wired or anchored devices limit the variety of exercises that can be measured, and may also present potentially more difficulty in managing data collection amongst several athletes simultaneously (Sato et al., 2015). Studies have examined the reliability and validity of wireless inertial sensor measurement compared to currently validated wired measurement tools like the GymAware (Orange et al., 2018). The use of specific algorithms to detect and measure different exercises restricts the extrapolation of results related to validity and reliability from one exercise to another (Sato et al., 2015). Few studies have been performed in relation to the validity of wireless inertia devices on measurement of vertical jumping performance. Therefore, the purpose of this study was to investigate the validity of a wireless measurement device on several types of vertical jump exercise. Specifically, this investigation examined static, countermovement, and drop jumps as measured with a wireless sensor compared with commercially available force plates.

METHODS: Twenty active individuals (10 males: 23.8±4.0 y, 77.1± 9.7 kg, 173.0±4.3 cm; 10 females: 21.5±1.3 y, 66.5±6.4 kg, 162.3±7.1 cm) participated in this study. All subjects signed and completed an informed consent prior to participation, which was reviewed and approved by the University's Institutional Review Board. Each individual was familiarized with the usage of the PUSH Band wearable sensor (PUSH™,, PUSH, Inc. Canada) and the force plates (2 separate 750mm x 250mm force plates; Vald Performance, Brisbane, QLD) prior to testing. The subjects were then given instructions on each jumping condition for each of the three vertical jump variations. Static jumps (SJ) were performed by having the subject place a near weightless polyvinyl chloride pipe (PVC) on their upper back in a back squat position and having the athlete squat down to 90° of knee flexion confirmed by a goniometer and complete a concentric only vertical jump after a countdown of "3, 2, 1, jump!" from the researcher. Countermovement jumps (CMJ) were performed by placing the PVC pipe in the back squat position and having the athlete perform a CMJ after a countdown of "3, 2, 1, jump!" from the researcher. Depth jumps (DJ) were completed from a 45cm plyometric box placed in front of the force plates. For safety and balance, an arm swing was allowed on DJ. Subjects were instructed to lead off with one foot, prepare for landing, and jump as high as possible following contact. Following this familiarization, each subject performed a standardized warm up consisting of walking lunges, jumping jacks, and body weight squats. Following the warm up protocol, each athlete performed 10 vertical jumps of each jumping condition for a total of 30 jumps. The PUSH Band wireless sensor was worn on the waist, centered over the sacrum. The subjects performed all jumps on the force plates. Data from the wireless sensor and force plates was collected simultaneously.

Variables collected from this investigation were peak power (PP) and jump height (JH) for SJ and CMJ. Peak power and the reactive strength index (RSI) were collected for DJ. The PUSH Band data was collected from the PUSH Band using the PUSH Online Portal via Bluetooth to a wireless tablet and analyzed using the Train with Push software (iPad, Apple Inc., Cupertino, CA, USA). The force plate data was collected and analyzed using Force Deck software (Vald Performance, Brisbane, QLD). All data was collected at a sampling rate of 1000 Hz for both devices for the duration of the study. All variables for analysis were collected from the PUSH Band and force plates that were running concurrently and variables were obtained from outputs from their propriety software. Descriptive statistics of mean and standard deviation were calculated for all variables. Data was analyzed by using a paired Samples Statistics tests for all performance variables for each jump variety. Statistical significance was set at $p \leq 0.05$ for all statistical analysis. All statistical analysis was completed using SPSS 25 (IBM, New York, NY, USA).

RESULTS: Descriptive data and results of paired samples t-test for all variables can be found in Table 1. For all variables collected except for the reactive strength index, statistically significant differences were observed ($p \leq 0.05$) between measurements from the PUSH Band and the Force Decks.

TABLE 1. Descriptive statistics for All 200 Jump Trials

Jump Condition	Unit	Mean ± SD	*p*
SJJH (cm)	PB FD	38.74 ± 6.87 26.06 ± 7.49	< 0.001
SJPP(W)	PB FD	2818.33 ± 926.73 3164.24 ± 1007.35	< 0.001
CMJJH (cm)	PF FD	37.78 ± 7.79 25.52 ± 8.09	< 0.001
CMJPP(W)	PB FD	2959.21 ± 1003.29 3309.32 ± 1040.30	< 0.001
DJRSI (cm/ms)	PB FD	0.72 ± 0.33 0.70 ± 0.24	0.524
DJPP(W)	PB FD	5855.41 ± 2462.09 7785.75 ± 2323.54	< 0.001

*Note: SJ=Squat Jumps; CMJ=Countermovement Jumps; DJ=Drop Jumps; JH=Jump Height; PP=Peak Power; RSI=Reactive Strength Index; PB= Push Band; FD=Force Decks. * Significant difference ($p \leq 0.01$) between devices.*

DISCUSSION: The purpose of this study was to measure the validity of a wireless inertia sensor on variables related to performance in multiple vertical jumping exercises by comparing results to force plates. Overall, on all measures captured in this study, the inertia sensor was not in agreement with the force plates on any of the variables measured except for the reactive strength index. The sensor tended to inflate jump heights on both SJ (12.7cm) and CMJ (12.2cm). Discrepancies were found in PP measurements, with the sensor reporting lower values compared to the force plates for SJ (345W), CMJ (350W), and DJ (2,200W).

Our data diverges with data from (Sato et al., 2015) who found at slower speeds and controlled resistance exercise the wireless sensor and 3D motion capture were both in agreement for linear and curvilinear motion. It is important to note that the device was worn on the arm during the previous study, and worn around the waist above the sacrum in the present study, which may provide different results. A recent study (Orange et al., 2018) found the wireless sensor to be neither valid nor reliable in the back squat exercise when compared with a linear position transducer, except when compared in the measure of mean power. Our measurements against the force plates found the data not to be in agreement for jump height measured by flight time, however the data received from the wireless sensor was consistent in providing similar measurement each time it was sampled from the device. Some of the disagreement between devices could be due to the proprietary algorithms used for calculation of variables in question. Future studies should compare this device against both 3D motion capture devices and linear position transducers to determine the validity of these devices in measurement jump performance.

In conclusion, using this wireless sensor for jumping performance when compared with force plates provides data not valid for measurement of JH and PP in SJ, CMJ, and DJ. Measurement of RSI was acceptable from the analysis in this study. Other types of exercises requiring the PUSH wireless device to be worn by the athlete should be examined compared to either force plates or 3D motion capture analysis to determine validity and reliability. Between-device consistency could also be measured, as only one wireless device was utilized during this study; future studies should consider testing multiple units for a larger data pool. In order to reduce some of the variability between devices it is recommended that devices be assigned to specific players in order to monitor long term changes. Wireless sensors provide a lower cost option and time sensitive alternative for coaches and athletes to monitor their performance during a training session and longitudinally for training adaptations. Utilizing units across a team offers a novel way to quickly establish benchmark performance variables at various points during the competitive season and training year, giving coaches objective feedback while using time already set aside for training, as opposed to separate testing sessions or utilizing one piece of equipment. The software frequently paired with wireless devices, and especially the PUSH Band, offers a more simplistic interface for coaches to monitor performance variables in real-time and remain mobile in a gym setting. Data collected with this method is easily organized and can be easily distributed among several individuals. Further research is warranted in order to determine the measurement validity of this device against other competing wireless devices to the current gold standard measurement options.

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