



Original research

Validity of the Polar Team Pro Sensor for measuring speed and distance indoors



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ARTICLE INFO

Article history:

Received 29 January 2019

Received in revised form 20 June 2019

Accepted 21 June 2019

Available online 27 June 2019

Keywords:

Accelerometer
Microsensor
Court-Based sport
Training load
Team sport

ABSTRACT

Objectives: To assess the validity of the Polar Team Pro Sensor for measuring speed and distance indoors during continuous locomotive and change-of-direction tasks at low, medium, and high intensities.

Design: Descriptive validation study.

Methods: 26 recreationally-active participants (age: 32.2 ± 11.0 yr; stature: 173.3 ± 9.9 cm; body mass: 74.2 ± 16.2 kg) completed three trials of low- (walking speed), medium- (jogging speed), and high-intensity (maximal sprinting speed) continuous locomotive and change-of-direction tasks. Participants wore back- and chest-mounted sensors to determine mean speed and total distance covered. One-way analysis of variance, t-tests, Pearson's Product moment correlation, and Bland–Altman plots were utilised to compare the speed and distance measured with the back- and chest-mounted sensors to reference measures (measured distance of the court via a trundle wheel and speed derived from measured distance and electronic timing lights).

Results: Speed and distance measured using the back- and chest-mounted sensors showed wide limits of agreement, which increased at high intensities for speed. The sensors typically underestimated speed and distance by as much as 2.76 km h^{-1} and 32.6 m, and overestimated speed and distance by as much as 4.52 km h^{-1} and 59.6 m across tasks and intensities compared to reference measures (168.45 and 40.00 m).

Conclusions: There was low agreement between both back- and chest-mounted sensors and the reference devices for measuring speed and distance indoors. Practitioners should understand the limitations and potential for error when using the Polar Team Pro Sensors indoors to measure speed and distance during continuous locomotive and change-of-direction tasks.

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Practical implications

- Mounting sensors on the back and chest may not be ideal for measuring speed and distance in court-based team sports played indoors.
- At higher intensities, error in speed measurement increased using back- and chest-mounted positioning with the Polar Team Pro Sensors.
- Alternative placement of the Polar Team Pro Sensors or measures of assessing speed and distance indoors should be considered.

1. Introduction

Monitoring training and competition demands in team sports requires an understanding of the stimulus imposed (i.e., external workload) and the players' physiological responses to the stimulus (i.e., internal workload).¹ In this regard, a dose-response relationship exists between external and internal workloads.² Specifically, while internal workload will ultimately dictate the adaptations that occur as a result of training and competition, it is the external workload that must be manipulated to bring about the desired responses from players.^{1,3} Therefore, it is important for team sport practitioners to accurately quantify external workloads during training and competition. In field-based team sports, external workload is generally reported as total or high-intensity distance travelled during training and competition.^{4,5} To provide these metrics, speed

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and distance are measured using global positioning systems (GPS), which have been shown to be valid^{6,7} and reliable^{6,7} in field settings. However, in indoor court-based team sports, signal interference prohibits the use of GPS technology.^{6,7}

Video-based time-motion analysis (TMA) is a valid⁸ and reliable,^{8,9} alternative for measurement of speed and distance indoors, but data analysis requires expertise and is time intensive, restricting its applicability for routine player monitoring.¹⁰ Local positioning systems (LPS), such as ultra-wide band or radiofrequency identification systems, are an alternative approach for measuring speed and distance indoors^{11,12}; however systems are often cost-prohibitive and not available at all training and competition venues. Given the limitations of various approaches, microsensor-based monitoring systems have emerged as a common method for objectively monitoring external workload indoors.^{13–15}

Microsensors typically encompass tri-axial accelerometers, gyroscopes, magnetometers, or a combination of these instruments.¹⁶ In accordance with manufacturers' instructions, microsensors are commonly positioned on the upper-back between the scapulae in a specifically-designed garment¹⁰ and therefore do not impede player movement during training and competition. Furthermore, the use of proprietary software allows for efficient processing and analysis of external workload data for feedback into player management strategies.¹⁰ Consequently, the ease of use and efficiency of data collection and processing makes microsensors practically appealing for monitoring external workload indoors. While microsensors have traditionally been used to provide external workload metrics in indoor, court-based sports, these metrics are commonly reported in arbitrary units (AU) rather than speed and distance. Arbitrary units can be difficult to interpret as currently no thresholds exist for categorising low, medium, and high external workloads derived from accelerometers. The use of arbitrary units is also problematic as it is possible for players to obtain similar external workloads where the session is comprised of consistent medium-intensity activity or a combination of low and high-intensity activity, despite providing different stimuli to players.

The Polar Team Pro Sensor is a newly-developed microsensor system for measuring speed and distance indoors. The Polar sensors integrate GPS, in addition to an accelerometer, gyroscope, and digital compass, that records data at 200 Hz with a range up to 200 m.¹⁷ For indoor monitoring, multiple sensors coupled with in-built heart rate monitoring and proprietary software to determine speed and distance without utilising GPS capabilities, make these devices attractive compared to other workload monitoring systems. The algorithms used to determine speed and distance using the sensors are not disclosed; however, no GPS signalling is utilised making the sensors suited to indoor environments. However, the validity of the Polar Team Pro Sensors for measuring speed and distance indoors has yet to be determined. Therefore, the primary aim of this study was to determine the validity of the Polar Team Pro Sensors in measuring speed and distance indoors during continuous locomotive and change-of-direction (COD) tasks. The secondary aim of this study was to determine whether device positioning (back-mounted vs chest-mounted) influences the validity of speed and distance measurement.

2. Methods

To ensure the study was sufficiently powered ($\alpha=0.05$ (two-tailed), $\beta=0.80$, medium effect (0.5); G*Power, version 3.1.9.2, University of Duffeldorf; Duffeldorf, Germany), 26 recreationally-active participants (age: 32.2 ± 11.0 yr; stature: 173.3 ± 9.9 cm; body mass: 74.2 ± 16.2 kg) volunteered to participate in this study.

Prior to study commencement, participants were screened for any injuries or health conditions that prevented them from safely participating using Stages 1 and 2 of the Adult Pre-Exercise Screening System.¹⁸ All participants were provided with an information sheet outlining the purpose of the study and any risks and benefits of participation before providing written informed consent prior to testing. All procedures were approved by an institutional Human Research Ethics Committee.

Participants attended a single testing session where stature (portable stadiometer, Seca 213, Seca GMBH, Hamburg, Germany) and body mass (electronic scales, BWB-600, Tanita Corporation, Tokyo, Japan) were measured prior to testing. Participants were fitted with two randomly-selected sensors (Polar Team Pro Sensor, Polar Electro, Kempele, Finland) from a lot of 14 Sensors, allocated using a random number generator in Microsoft Excel (Version 15.0, Microsoft Corporation, Redmond, WA, USA). One sensor was positioned on the upper-torso between the scapulae (back-mounted) in a specifically-designed shirt (Polar Electro, Kempele, Finland), and the other sensor was positioned on the centre of the chest at the level of the xiphoid process (chest-mounted) via a specifically-designed strap (Polar Electro, Kempele, Finland) worn in accordance with the manufacturer's instructions. Participants then completed continuous locomotive and COD tasks in a randomised order. For both tasks, participants were required to complete three trials at self-selected low (slow, walking speed), medium (moderate, jogging speed), and high (maximal, sprint speed) intensities. Participants were advised to maintain consistent walking, jogging, and sprint speeds, respectively for each trial. Distance for each task was measured using a trundle wheel and the precise movement paths were marked on the court to ensure the measured distance was followed. All testing was conducted on a sprung hardwood floor in an enclosed stadium. Temperature was controlled during all testing sessions to ensure similar environmental conditions for all participants. For each trial of the continuous locomotive task, participants were required to complete one lap of a rectangular indoor stadium (168.45 m) following markings on the court. The COD task involved completion of the Agility T-test,¹⁹ which consisted of a 10-m forwards run, 5-m lateral shuffle to the left, 10-m lateral shuffle to the right, 5-m lateral shuffle to the left, and 10-m backwards run to the original starting position (40 m total). Between each trial, a member of the research team saved the data from the previous trial using the Polar Team Pro application (version 1.9.9, Polar Electro, Kempele, Finland) before the next trial commenced. Using the Polar Team Pro application, each trial commenced and finished as each participant passed an electronic timing light (Fusion Sport, Coopers Plains, QLD, Australia). This system uses a single-beam design and novel error detection algorithms to limit the likelihood of a false trigger. The timing light was placed at the start/finish line for each task and used to determine the actual (reference) speed. Specifically, reference speed was determined as the measured distance divided by the time taken to complete each trial. Following the testing session, speed and distance data from the sensors were exported from the Polar Team Pro online platform (teampro.polar.com) to a personal computer for analysis.

Using a specifically-designed spreadsheet (Microsoft Excel Version 15.0, Microsoft Corporation, Redmond, WA, USA), Bland–Altman plots with adjusted limits of agreement to account for repeat observations²⁰ were developed for each task with low, medium, and high intensities combined, to assess the agreement in speed and distance measurement between the back-mounted sensors, chest-mounted sensors, and the reference measures. Heteroscedasticity of the data for each Bland–Altman plot for speed was tested with the Breusch–Pagan test using XLStats add-in (Version 2018.7, Addinsoft, Boston, USA) for Microsoft Excel. Where heteroscedasticity reached statistical significance, v-shaped limits of agreement were applied as previously described.²¹ Given the use

of a fixed value (zero variance) for distance, the presence or otherwise of heteroscedasticity in distance measurement could not be assessed in the present study.

Speed and distance recorded with the back- and chest-mounted sensors for each task at each intensity are reported as mean \pm standard deviation (SD). The three trials of each task at each intensity were pooled in the analyses. One-way analysis of vari-

ance (ANOVA) with Bonferroni post hoc tests and Cohen's effect sizes (d) with 95% confidence intervals were utilised to determine whether speed recorded with the back- and chest-mounted sensors differed from each other or from the reference speeds during each task at each intensity. One-sample t-tests and Cohen's effect sizes (d) with 95% confidence intervals were used to compare speed measured with the back- and chest-mounted sensors

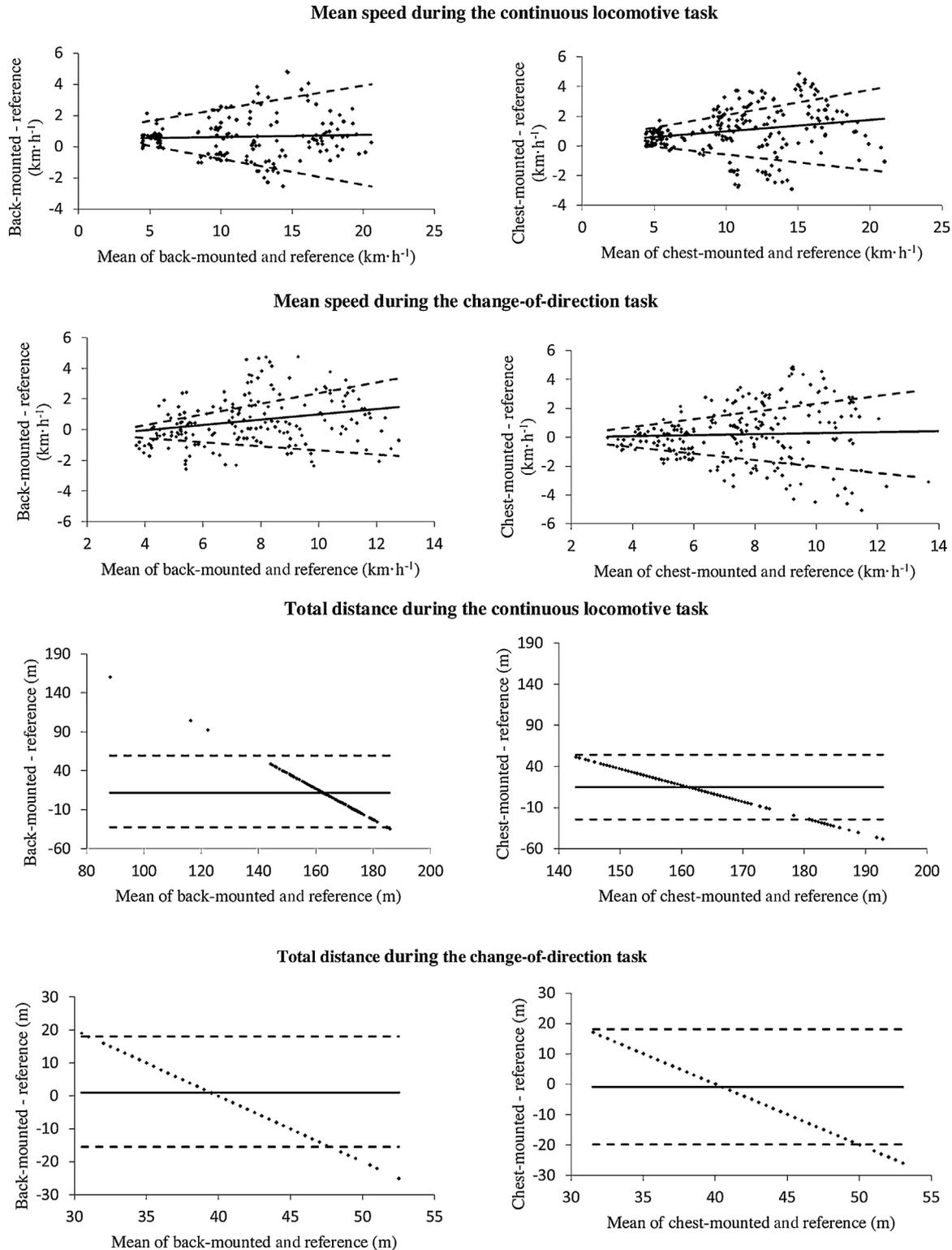


Fig. 1. Bland-Altman plots with 95% Confidence Intervals comparing speed and distance from the back- and chest-mounted sensors to the reference values during the continuous locomotive and change-of-direction task.

Table 1Mean speed and mean total distance (mean \pm standard deviation) recorded with the back-mounted sensor, chest-mounted sensor, and the reference device.

	Continuous locomotive task			Change-of-direction task		
	Back-mounted sensor	Chest-mounted sensor	Reference	Back-mounted sensor	Chest-mounted sensor	Reference
Speed (km h ⁻¹)						
Low-intensity	5.16 \pm 1.0*	5.02 \pm 0.71*	5.63 \pm 0.73	5.08 \pm 0.75	5.26 \pm 1.07	4.92 \pm 0.79
Medium-intensity	9.91 \pm 1.3*	9.59 \pm 1.38*	10.77 \pm 1.71	7.19 \pm 1.11*	7.76 \pm 1.69**	7.85 \pm 1.12
High-intensity	15.46 \pm 2.36	14.77 \pm 2.22*	15.98 \pm 2.61	9.40 \pm 1.91*	9.45 \pm 2.17	10.26 \pm 1.56
Distance (m)						
Low-intensity	148.18 \pm 27	150.78 \pm 11.09	168.45 \pm 0	43.13 \pm 9.08	43.46 \pm 7.33	40.0 \pm 0
Medium-Intensity	156.42 \pm 22.26	152.33 \pm 24.11	168.45 \pm 0	36.89 \pm 7.29	40.60 \pm 9.99**	40.0 \pm 0
High-intensity	162.77 \pm 19.28	157.63 \pm 21.52	168.45 \pm 0	37.09 \pm 7.73	38.73 \pm 10.53	40 \pm 0

* Indicates significant ($p < 0.05$) difference to reference measure.** Indicates significant ($p < 0.05$) difference to back-mounted sensors.

to the reference (measured) distance and paired t-tests were used to identify differences in speed measured with the back- and chest-mounted sensors. Effect size magnitudes were interpreted as: *trivial* = < 0.2 , *small* = 0.2 – 0.59 , *moderate* = 0.6 – 1.19 , *large* = 1.2 – 1.99 , *very large* = 2.0 – 3.99 and *nearly perfect* = ≥ 4.0 .²²

Pearson's Product-Moment correlations examined the strength of any relationships between speed recorded with the back-mounted sensors, chest-mounted sensors, and timing lights and between distance measured with the back- and chest-mounted sensors during each task at each intensity. Correlation magnitudes were interpreted as: *trivial* = < 0.1 , *small* = 0.1 – 0.29 , *moderate* = 0.3 – 0.49 , *large* = 0.5 – 0.69 , *very large* = 0.7 – 0.89 , *nearly perfect* = 0.9 – 0.99 , and *perfect* = 1 .²² All analyses were conducted using IBM SPSS statistics (Version 25, IBM Corporation, Armonk, NY). Significance was accepted where $p < 0.05$.

3. Results

Bland–Altman plots with 95% confidence intervals are presented in Fig. 1. Significant heteroscedasticity was identified for all speed plots. For the continuous locomotive task, the mean difference in speed and distance between the back-mounted sensors and reference device was 0.62 km h^{-1} and 11.56 m , and the mean difference in speed and distance between the chest-mounted sensors and reference device was 0.99 km h^{-1} and 14.85 m , respectively. For the COD task, the mean difference in speed and distance between the back-mounted sensors and reference device was 0.58 km h^{-1} and 1.03 m , and the mean difference in speed and distance between the chest-mounted sensors and reference device was 0.91 km h^{-1} and 0.19 m , respectively. The back-mounted sensors underestimated speed and distance by as much as 2.4 km h^{-1} (15%) and 36.6 m (22%), and overestimated speed and distance by as much as 4.2 km h^{-1} (26%) and 59.6 m (35%) during the continuous locomotive task. The chest-mounted sensors underestimated speed and distance by as much as 1.7 km h^{-1} (11%) and 24.5 m (15%), and overestimated speed and distance by as much as 4.5 km h^{-1} (28%) and 54.4 m (32%) during the continuous locomotive task. The back-mounted sensors underestimated speed and distance by as much as 1.7 km h^{-1} (17%) and 15.5 m (39%), and overestimated speed and distance by as much as 3.4 km h^{-1} (33%) and 18.0 m (45%) during the COD task. The chest-mounted sensors underestimated speed and distance by as much as 2.8 km h^{-1} (27%) and 19.8 m (50%), and overestimated speed and distance by as much as 3.2 km h^{-1} (31%) and 18.1 m (45%) during the COD task.

Means \pm SD for each outcome measure are presented in Table 1. Results of all pairwise comparisons are presented in Table 2. During the continuous locomotive task, ANOVAs revealed a significant difference between devices for speed at low ($p < 0.001$), medium ($p < 0.001$), and high intensities ($p = 0.008$). At low and medium intensities, back- and chest-mounted sensors recorded slower

speeds than the timing lights. At high intensities, chest-mounted sensors recorded slower speeds than the timing lights.

During the COD task, there was a significant difference between devices for speed at medium ($p = 0.01$) and high intensities ($p = 0.008$). The back-mounted sensor recorded slower speeds than the chest-mounted sensor and the timing lights at medium intensities, and back- and chest-mounted sensors recorded slower speeds than the timing lights at high intensities.

During the COD task, the back-mounted sensor recorded shorter distances compared with the chest-mounted sensor at medium intensities ($p < 0.05$).

Correlation magnitudes between devices for speed and distance are presented in Table 2. During the continuous locomotive task, correlations across speeds between the back-mounted sensors, chest-mounted sensors, and the reference device were significant and moderate to very large. During the COD task, there was a significant, large correlation between speed measured with the chest-mounted sensors and the reference device at low intensities and there was a significant, moderate correlation between speed measured with back-mounted sensors and the reference device at high intensities. During the COD task, there were significant, moderate to very large correlations between speeds recorded with the back- and chest-mounted sensors at low, medium, and high intensities. During the continuous locomotive task, there were significant, large correlations between distance measured with the back- and chest-mounted sensors at medium and high-intensities. During the COD task, there were significant, large correlations between distance measured with the back- and chest-mounted sensors at low, medium, and high-intensities.

4. Discussion

This study is the first to examine the validity of the Polar Team Pro Sensors for measuring speed and distance indoors. There was good agreement between the back- and chest-mounted sensors for speed and distance measurement, but both placements compared poorly to the reference measures. Specifically, the sensors underestimated speed and distance by as much as 2.76 km h^{-1} and 32.6 m , and overestimated speed and distance by as much as 4.52 km h^{-1} and 59.6 m across tasks and intensities. Furthermore, limits of agreement for speed between back- and chest-mounted sensors and the reference devices increased at higher intensities. The wider limits of agreement suggest that at higher intensities, the margin of error in measuring speed increases.

The present findings support previous literature showing microsensors utilising tri-axial accelerometer data possess limited capacity to detect accelerations during running-based tasks,²³ which likely explains the wide limits of agreement during the continuous locomotive task. Specifically, back-mounted accelerometers such as those used in the present study tend to provide a poor representation of vertical acceleration compared to

Table 2
Correlations and differences between devices for speed and distance measured during the linear and change-of-direction tasks.

Variable	Device comparison	Intensity	Correlation [r, interpretation, p value]	Statistical differences [effect size (95% CI), interpretation, p value]
Speed (km h ⁻¹)	Continuous locomotive	Low		
	Back-mounted sensor vs reference	Low	0.887, <i>very large</i> , <0.001*	0.52 (0.16, 0.91), <i>small</i> , 0.006**
	Chest-mounted sensor vs reference	Low	0.843, <i>very large</i> , <0.001*	0.85 (0.51, 1.17), <i>moderate</i> , < 0.001**
	Back-mounted vs chest-mounted sensors	Low	0.83, <i>very large</i> , 0.001*	0.16 (–0.21, 0.53), <i>trivial</i> , 1.00
	Back-mounted sensor vs reference	Medium	0.634, <i>large</i> , <0.001*	0.56 (0.19, 0.90), <i>small</i> , 0.005**
	Chest-mounted sensor vs reference	Medium	0.489, <i>moderate</i> , <0.001*	0.76 (0.43, 1.08), <i>moderate</i> , < 0.001**
	Back-mounted vs chest-mounted sensors	Medium	0.629, <i>large</i> , <0.001*	0.24 (–0.11, 0.59), <i>small</i> , 0.7
	Back-mounted sensor vs reference	High	0.785, <i>very large</i> , <0.001*	0.21 (–0.11, 0.53), <i>small</i> , 0.564
	Chest-mounted sensor vs reference	High	0.674, <i>large</i> , <0.001*	0.50 (0.18, 0.82), <i>small</i> , 0.006**
	Back-mounted vs chest-mounted sensors	High	0.826, <i>very large</i> , <0.001*	0.30 (–0.02, 0.62), <i>small</i> , 0.242
	Change-of-direction			
	Back-mounted sensor vs reference	Low	0.153, <i>small</i> , 0.24	0.21 (–0.13, 0.54), <i>small</i> , 0.856
	Chest-mounted sensor vs reference	Low	0.503, <i>large</i> , <0.001*	0.36 (0.04, 0.68), <i>small</i> , 0.052
	Back-mounted vs chest-mounted sensors	Low	0.717, <i>very large</i> , <0.001*	0.19 (–0.15, 0.53), <i>trivial</i> , 0.706
	Back-mounted sensor vs reference	Medium	0.24, <i>small</i> , 0.058	0.59 (–0.17, 0.93), <i>small</i> , 0.013**
	Chest-mounted sensor vs Reference	Medium	0.081, <i>trivial</i> , 0.48	0.06 (–0.25, 0.38), <i>trivial</i> , 1.00
	Back-mounted vs chest-mounted sensors	Medium	0.462, <i>moderate</i> , <0.001*	0.40 (0.05, 0.72), <i>small</i> , 0.043**
	Back-mounted sensor vs reference	High	0.448, <i>moderate</i> , <0.001*	0.49 (0.16, 0.83), <i>small</i> , 0.023**
	Chest-mounted sensor vs reference	High	0.141, <i>small</i> , 0.218	0.43 (0.11, 0.74), <i>small</i> , 0.024**
	Back-mounted vs chest-mounted sensors	High	0.548, <i>large</i> , <0.001*	0.02 (–0.35, 0.30), <i>trivial</i> , 1.00
	Continuous locomotive	Low		
	Back-mounted vs chest-mounted sensors	Low	0.028, <i>trivial</i> , 0.856	0.13 (–0.23, 0.51), <i>trivial</i> , 0.46
	Back-mounted vs chest-mounted sensors	Medium	0.642, <i>large</i> , <0.001*	0.18 (–0.18, 0.52), <i>trivial</i> , 0.329
	Back-mounted vs chest-mounted sensors	High	0.640, <i>large</i> , <0.001*	0.25 (–0.07, 0.57), <i>small</i> , 0.128
Distance (m)	Change-of-direction			
	Back-mounted vs chest-mounted sensors	Low	0.679, <i>large</i> , <0.001*	0.679, <i>large</i> , <0.001*
	Back-mounted vs chest-mounted sensors	Medium	0.620, <i>large</i> , <0.001*	0.42 (0.08, 0.75), <i>small</i> , 0.012**
	Back-mounted vs chest-mounted sensors	High	0.647, <i>large</i> , <0.001*	0.18 (–0.16, 0.50), <i>trivial</i> , 0.286

* Indicates significant correlation (p < 0.05).

** Indicates significant difference (p < 0.05); CI = confidence interval.

criterion measures of three-dimensional video analysis^{23,24} and a force platform.²³ The low sensitivity to vertical acceleration might be attributed to the absence of significant vertical trunk movement during running.²⁵ As such, the back- and chest-mounted Polar Team Pro Sensors may not be ideal for speed and distance measurement during continuous locomotive activities.

Previous studies^{25,26} reported accelerometers mounted on the hip exhibited better validity in quantifying external workload during running than back-mounted accelerometers due to a closer proximity to the centre of mass. Placement close to the centre of mass increases the sensitivity of accelerometers in detecting movement at the lower-limb, such as higher mediolateral accelerations, which are indicative of increased running speeds.^{25,26} Interestingly however, our data showed good agreement between the back- and chest-mounted sensors for measuring speed and distance during the continuous locomotive task. However, it is possible that the difference in positioning between the back- and chest-mounted sensors was too small to manifest as a noticeable difference in validity for speed and distance measurement. Nevertheless, the poor representation of speed and distance during running suggests that either back- or chest-mounted placements of the Polar Team Pro Sensors may not be ideal for measuring the speed and distance of continuous locomotive tasks during training and competition in indoor court-based sports.

In comparison to the poor validity of the sensors during the continuous locomotive task, limits of agreement for speed were smaller for the COD task. This finding may be due to the multi-directional accelerations and decelerations encountered during the COD task. Specifically, rapid changes of direction such as those underpinning the COD task create increased movement at the torso,²⁴ that were likely detected with the back- and chest-mounted sensors. However, consistent with continuous locomotive tasks, limits of agreement for speed during COD tasks increased at high intensities and this has important implications for practitioners. Quantifying the external workloads associated with high-intensity running

and changes-of-direction during training and competition is an important factor in understanding the demands placed on players participating in court-based sports.¹ However, the poor validity in speed measurement, particularly at higher intensities using the Polar Team Pro Sensors, limits the ability to precisely quantify external workloads and subsequently make decisions regarding when they may need to be modified. Furthermore, though speeds were classified as low, medium, and high intensities, the mean speeds obtained during the continuous locomotive and COD tasks failed to reach those previously reported during actual competition during indoor court-based sports such as basketball.⁶ If the trend of poorer agreement at higher speeds observed in our study is extrapolated, agreement between the sensors and the reference device may worsen at speeds representative of competition. While there are certain practical and financial limitations concerning the use of TMA and LPS for player monitoring indoors, these sensors allow for speed and distance to be validly determined. For example, bias (typical errors) in speed and distance measures previously reported using LPS was 1.2–9.3%¹² compared to 11–50% in the present study. Importantly, when using technology such as TMA or LPS, speed is typically categorised into intensity zones to represent the nature and demands of training and competition.⁸ Therefore, poor agreement between speed measured using the sensors and reference device may cause intensities to be classified inaccurately with the Polar Team Pro Sensors. As such, players may be susceptible to negative outcomes associated with the prescription of insufficient or excessive training and competition stimuli such as illness or injury.^{27,28}

The present study provides novel insight regarding the validity of the Polar Team Pro Sensors for measuring speed and distance indoors, which should be considered alongside the limitations of the methods and the approach. During the testing, each trial was manually started and stopped using the Polar Team Pro application as the participant passed the timing lights which may have led to a small discrepancy in the times recorded. In addition, partici-

pants completed a continuous locomotive and COD task; however, these tasks do not replicate the entire movements performed during training and competition in court-based sports. Therefore, the validity of the Polar Team Pro Sensors for measuring speed and distance in scenarios involving jumping or continuous locomotive and multidirectional movements completed in close succession are still unclear. It should also be recognised that participants were required to complete 90° changes-of-direction during the continuous locomotive and COD tasks, which creates potential error in the reference speed and distance measures if the exact path is not followed by participants. As such, the validity of these devices should be further assessed using data from a true gold standard (criterion) measure such as a motion capture system. Furthermore, the primary aim of the present study was to assess validity; however, a measure of reliability is also necessary to assess the usefulness of these devices in an applied setting. Finally, the placements investigated (back- and chest-mounted) were those recommended by the manufacturer; however, these placements may not be ideal for measurement of speed and distance. Extending on our findings, more work should be conducted to investigate the validity of speed and distance measures of the Polar Team Pro Sensors positioned closer to the centre of mass such as at the hip. However, it should be recognised the Polar Team Pro Sensors commence recording data when a GPS or HR signal is detected and therefore studies would need to consider these logistical constraints. Similarly, moving the placement of the sensors away from the back- and chest-mounted placements supported by the manufacturer may prohibit collection of HR data which is obtained via the Polar Team Pro shirt or strap, therefore limiting the practical advantages of these devices in being able to concurrently monitor external and internal workloads.

5. Conclusion

This study is the first to examine the validity of the Polar Team Pro Sensors for measuring speed and distance during continuous locomotive and COD tasks indoors. The sensors underestimated speed and distance by as much as 2.76 km h⁻¹ and 32.6 m, and overestimated speed and distance by as much as 4.52 km h⁻¹ and 59.6 m across tasks and intensities. Furthermore, the limits of agreement for speed increased at higher intensities in both tasks. Therefore, practitioners should exercise caution when using the Polar Team Pro Sensors for measuring speed and distance indoors.

Acknowledgements

This research was funded by the National Strength and Conditioning Association (NSCA) Foundation; however, the funding body had no involvement in the study.

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