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Validity of thorax-worn GPS heart rate data during continuous incremental and intermittent running

Thomas Fary [a,b,c,*], Grant Duthie [a,b], Patrick Campbell [a,b], Jacob Jennings [c,d], David Ballard [c], Michael Speranza [c], Rich Johnston [a,b,e]

[a] School of Behavioural and Health Sciences, Australian Catholic University, Australia
[b] Sports Performance, Recovery, Injury and New Technologies (SPRINT) Research Centre, Australian Catholic University, Australia
[c] Brisbane Broncos Rugby League Club, Australia
[d] Holsworth Research Initiative, La Trobe Rural Health School, La Trobe University, Australia
[e] Carnegie Applied Rugby Research (CARR) Centre, Institute for Sport, Physical Activity and Leisure, Leeds Beckett University, United Kingdom

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ABSTRACT

Objectives: To determine the level of agreement between Catapult Vector S7 and Polar H10 for measuring heart rate (HR) during continuous incremental and intermittent running.
Design: Concurrent validity study.
Methods: Twenty participants (n = 10 males, 10 females; age = 25.7 ± 4.9 years) completed a continuous incremental and intermittent running protocol on a motorised treadmill with HR measured wearing Catapult Vector S7 and Polar H10 devices. The continuous protocol involved incremental increases in speed at a fixed 1 % incline until at least 90 % of age-predicted heart rate max (HR_{max}) was reached. The intermittent protocol was completed following a standardised recovery period. Coefficient of determination (R^2), root mean square error (RMSE), mean absolute percentage error (MAPE), mean bias, and 95 % limits of agreement (LoA) were used to measure agreement between the two devices.
Results: Near-perfect agreement ($R^2 = 0.99$ for all participants) between the two devices was observed for the continuous and intermittent protocols. The RMSE was low for all participants, measuring 1.6 beats per minute (bpm) during the continuous protocol and 1.2 bpm during the intermittent protocol. No systematic bias was observed in either protocol when grouped by sex. Although females showed slightly higher RMSE values in both the continuous (2.2 vs 0.7 bpm) and intermittent protocols (1.5 vs 0.8 bpm), the Vector S7 validity remained high.
Conclusions: The Catapult Vector S7, in combination with Vector Elite 2.3 Vest, represents a highly valid alternative to chest-worn straps in measuring HR during high-intensity exercise involving continuous and intermittent running.

Practical implications

- The Catapult Vector S7 in combination with Vector Elite Vest 2.3 is a valid method for measuring HR during high-intensity exercise involving continuous and intermittent running activity.
- The approach offers a practical alternative to chest-worn HR devices, minimising the need for multiple wearable devices and enabling simultaneous collection of internal and external load data.
- Although HR data were slightly less accurate for female participants, the difference was practically negligible, supporting the use of Vector S7 in female athletes. Practitioners should, however, take care to ensure that vest electrode contact is not compromised by sports bras or other garments.

1. Introduction

Heart rate (HR) is widely used in team sports to monitor athletes' internal training load response.[1,2] As a non-invasive tool, HR monitoring enables routine physiological assessments of athletes, providing performance staff with insights into positive adaptations (indicative of increased cardiorespiratory fitness) and negative outcomes such as maladaptation or fatigue.[1,2] Electrocardiography (ECG) is the gold-standard for HR monitoring, providing precise R-R wave interval measurements; however, its use is largely restricted to laboratory settings due to its impracticality in field-based settings.[3] To overcome the limitations of ECG in sporting environments, chest-worn HR monitors with embedded ECG electrodes have

* Corresponding author.
E-mail address: thomas.fary@myacu.edu.au (T. Fary).
Social media: @TomFary (T. Fary).

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been developed,[3,4] offering higher accuracy than wrist and arm-worn sensors using photoplethysmography technology.[4–6]

Chest-worn HR monitors such as the Polar H10 (Polar Electro Oy Kempele, Finland) and Garmin HRM-Pro (Garmin Ltd., Southampton, UK) have demonstrated high validity and reliability in controlled, lab-based high-intensity exercise protocols.[7–9] One study found that the Polar H10 demonstrated superior signal quality (99.4 %) compared to a 5-lead ECG (87.8 %) during high-intensity treadmill jogging and strength training, with significantly fewer R-R interval detection errors.[7] Although chest-worn HR monitors are a practical and valid measure of HR, their application in physical contact-based sports can present challenges. High-force impacts (e.g., tackling or collisions) can cause athlete discomfort and shift or dislodge the chest strap or device,[3] whilst also introducing motion artefacts that degrade ECG signal quality and ultimately reduce HR data accuracy.[3,10]

A potential alternative to chest-worn HR devices is the use of wearable HR vests, which may minimise discomfort and risk of displacement during physical contact by positioning the HR measurement device between the scapulae rather than the chest. These wearable HR vests integrate electrodes on the chest, which transmit real-time HR data to a global positioning system (GPS) device. For example, Catapult Sports wearable HR vest (Vector Elite Vest 2.3, Catapult Sports, Melbourne, Australia) integrates this functionality within the GPS unit (Vector S7, Catapult Sports, Melbourne, Australia) which receives the HR signal. Whilst integrated HR wearable vests are increasingly used in elite sport settings, there has been limited research determining their validity. One study compared the accuracy of the Suunto Movesense sensor (Suunto Oy, Vantaa, Finland) when worn in a chest strap versus when integrated into a wearable HR vest (Bromely Sports, Sialkot, Pakistan).[11] They reported that the chest strap was more accurate than the vest, with a mean absolute percentage error (MAPE) of 0.8 % versus 3.3 % during various low-intensity activities, such as jogging at ~8 km/h for 10 min and stair running for 1 min.[11] However, participant data in the study's appendix reveals three individual HR vest observations with markedly high error (MAPE ≥8 % for average HR), whilst all other measurements were ≤1 %.[11] These outliers may have been due to improper vest fit or electrode placement, and therefore further work is required to understand the efficacy of vest-derived HR.

Given the importance of valid and reliable data to inform athlete training load monitoring,[12] it is imperative to understand how well wearable HR vests agree with a validated HR chest strap. Therefore, the aim of this study is to assess the concurrent validity of the Catapult Vector S7, housed within the Vector Elite Vest 2.3, in comparison to the Polar H10 during continuous incremental and intermittent running. Assessing different running-based exercise modalities is important, as team sports demand both low-intensity, sustained and intermittent high-intensity efforts.[13,14] Specifically, this study aims to determine (1) the level of agreement between the two devices and (2) the concurrent validity of the Vector S7 during different running-based protocols, including its ability to accurately capture HR fluctuations during intermittent running.

2. Methods

2.1. Participants

Twenty healthy, recreationally active participants (n = 10 males and 10 females; age = 25.7 ± 4.9 years) voluntarily participated in this study. Prior to testing, all participants were informed of study procedures, potential risks and benefits before providing informed consent. Ethics approval was granted by the Australian Catholic University Human Research Ethics Committee (2024-3831H).

2.2. Protocol

Participants were instructed to refrain from caffeine for at least 12 h and to avoid strenuous physical activity for 24 h prior to testing. All testing was conducted indoors using a motorised treadmill in a controlled laboratory environment, where temperature and ambient conditions were maintained. Each participant was required to complete two separate activities, with the first of these being a continuous running protocol with incremental increases in speed, followed by an intermittent running protocol.

The objective of the continuous incremental protocol was to reach at least 90 % of age-predicted maximum heart rate (HR_{max}), which was calculated using Tanaka's formula ($HR_{max} = 208 - 0.7 \times \text{age}$).[15] For the continuous incremental protocol, male participants commenced at a speed of 7 km/h, whilst female participants commenced at 6 km/h. After each minute of the test elapsed, speed was increased whilst the treadmill remained fixed at 1 % incline for the entire duration of the test. For the first 3 min of the test the increase in speed was 1 km/h each minute, followed by 0.5 km/h thereafter. Testing proceeded until ≥90 % of age-predicted HR_{max} was achieved; the protocol was terminated at the completion of the stage at which 90 % of HR_{max} was achieved. The final running velocity was then recorded.

Prior to the start of the intermittent protocol, each participant had a recovery period of 20 min to allow HR to return towards resting levels. For the intermittent protocol, each participant performed 8 repetitions of 30:30 intervals (30 s of running followed by 30 s of passive rest) at a constant velocity. The velocity was set at 120 % of individual participant's final velocity attained during the continuous protocol. The treadmill was fixed at an incline of 1 % during the intermittent protocol, and care was taken to ensure that participants were comfortable transitioning on and off the treadmill whilst moving at speed.

The intermittent protocol was designed to reflect the periods of high- and low-intensity running activities which are characteristic of field-based team sports.[16–18] Although the protocol does not entirely replicate the running demands of intermittent team sports, this protocol affords an understanding of how accurately the devices capture fluctuations in HR due to changes in exercise intensity, as would occur during intermittent team sports.

2.3. Data collection

A 10-Hz GPS device (Vector S7, Catapult Sports, Melbourne, Australia, firmware version 8.8.0) was worn within the Vector Elite Vest 2.3. The GPS device is located between the scapulae on the thoracic spine, with the ECG-based HR sensors embedded in the front of the vest, positioned

Fig. 1. Positioning of Catapult Vector Elite Vest 2.3 and Polar Pro Strap for each participant.

Table 1
Validity of Catapult Vector S7 heart rate (raw beat-by-beat data) compared with Polar H10 during continuous and intermittent running protocols.

Model	Sex	R^2	RMSE (bpm)	MAPE (%)	Bias ± LoA (bpm)
Continuous	Male	1.00	0.7	0.4	−0.5 (−2.0 to 1.0)
	Female	0.99	2.2	0.7	−0.5 (−4.8 to 3.8)
	Both	0.99	1.6	0.5	−0.4 (−3.6 to 2.7)
Intermittent	Male	0.99	0.8	0.4	−0.5 (−2.1 to 1.0)
	Female	0.98	1.5	0.5	−0.4 (−3.3 to 2.5)
	Both	0.99	1.2	0.5	−0.5 (−2.8 to 1.9)
Combined	Male	1.00	0.8	0.4	−0.5 (−2.0 to 1.0)
	Female	0.99	1.9	0.6	−0.4 (−4.2 to 3.3)
	Both	0.99	1.4	0.5	−0.4 (−3.3 to 2.4)

Abbreviations: R^2, coefficient of determination; RMSE, root mean square error; MAPE, mean absolute percentage error; HR, heart rate; LoA, limits of agreement; bpm, beats per minute.

appropriately on the chest. Manufacturer sizing guides were used to ensure proper fit of the HR-integrated vest and data accuracy. Each participant wore a brand-new vest, used for the first time during data collection to support data accuracy. The Polar H10 (Polar Electro OY, Kempele, Finland) in addition to the Polar Pro Strap was worn directly below the vest, ensuring that the electrodes were not overlapping each other to minimise introduction of signal noise (Fig. 1). Female participants wore a sports bra over the vest and Polar strap, ensuring that the electrodes on both devices always remained in direct contact with the skin. Due to the simultaneous use of the Vector Elite Vest 2.3, the Polar H10 was positioned slightly lower on the chest than recommended by the manufacturer.

2.4. Data processing

The Catapult Vector S7 data were downloaded after each session using the manufacturer's proprietary software (OpenField, Catapult Sports, software version 3.13.0) and exported as raw .csv files in 10-Hz format. Polar H10 data were also downloaded using the manufacturer's proprietary software (Polar Flow, Polar Electro OY) and exported as raw .csv files in 1-Hz format. Due to differences in sampling frequency between the two devices, the GPS-integrated HR data were downsampled to 1 Hz to match the Polar H10. For each one-second interval, the first HR value was retained. Pilot testing comparing this approach with using the mean of all values within each one-second interval showed no differences in results. Time synchronisation was based on activity start and end times to ensure temporal alignment between the two datasets. Cross-correlation analysis was then performed using the *ccf* function from the R *stats* package to confirm temporal alignment between GPS-integrated and Polar H10 HR data. The lag with the highest correlation coefficient (*best_lag*) was extracted, and no lag adjustments were required.

All 1-second HR values for each participant were retained to provide a complete assessment of device agreement, including periods of device disagreement and potential outlier measurements, as these are continuously recorded in practice. For each participant and protocol, HR traces were visually inspected for obvious artefacts or errors related to device use, technology, or fit, with exclusion considered only if a substantial portion of the dataset was clearly erroneous; no data required removal.

2.5. Statistical analyses

To determine the level of agreement between the two devices, linear regression models were created using all HR values recorded at 1-second intervals. Separate models were created for the continuous and intermittent protocols, and a combined model which included both datasets. Within each model, GPS-integrated HR values were used as the explanatory variable, with the corresponding Polar HR used as the outcome variable. Following model fitting, residuals were assessed for heteroscedasticity and normality to confirm assumptions of linear regression were met. Model performance was evaluated using coefficient of determination (R^2), root mean square error (RMSE) and MAPE.

In addition, mean bias and 95 % limits of agreement (LoA) were calculated for all HR values, as well as average and peak HR across all participants and protocols. Average HR was calculated as the mean HR across each protocol for each participant, and peak HR was defined as the highest HR attained. These measures are commonly used in applied settings and provide insight into how these devices may perform in practice. Bland–Altman plots were created for all three measures (all HR values, average HR, and peak HR), to visually assess the agreement between the GPS and Polar devices. The 95 % LoA were calculated as the mean bias ± 1.96 × standard deviation of the differences.[19] All statistical analyses were conducted using R (version 4.4.1, R Core Team, Vienna, Austria), within the RStudio software environment (version 2024.12.0, RStudio, Inc.).

3. Results

The Catapult Vector S7 demonstrated near-perfect agreement with the criterion Polar H10 (Table 1). Validity across both protocols was

Table 2
Group mean summary heart rate data (average and peak, reported as mean ± SD across participants) from Catapult Vector S7 and Polar H10 during continuous and intermittent running protocols.

Protocol	Gender	Metric	Polar	Catapult	Bias ± LoA (bpm)
Continuous	Male	Test duration (s)	582 ± 85	582 ± 85	
		Finishing speed (km/h)	12 ± 1	12 ± 1	
		Average HR (bpm)	151 ± 7	151 ± 7	−0.4 (−0.7 to −0.2)
		Peak HR (bpm)	177 ± 5	177 ± 6	−0.2 (−2.2 to 1.8)
		% Age-Pred HR_{max} (%)	94 ± 0	94 ± 0	
	Female	Test duration (s)	558 ± 98	558 ± 98	
		Finishing speed (km/h)	11 ± 1	11 ± 1	
		Average HR (bpm)	153 ± 7	153 ± 7	−0.5 (−2.0 to 1.0)
		Peak HR (bpm)	180 ± 6	179 ± 7	−1.0 (−2.3 to 0.3)
		% Age-Pred HR_{max} (%)	94 ± 0	93 ± 0	
Intermittent	Male	Test duration (s)	480 ± 0	480 ± 0	
		Interval speed (km/h)	15 ± 1	15 ± 1	
		Average HR (bpm)	164 ± 6	164 ± 6	−0.6 (−0.8 to −0.4)
		Peak HR (bpm)	177 ± 5	176 ± 5	−0.6 (−1.6 to 0.4)
		% Age-Pred HR_{max} (%)	94 ± 0	94 ± 0	
	Female	Test duration (s)	480 ± 0	480 ± 0	
		Interval speed (km/h)	13 ± 1	13 ± 1	
		Average HR (bpm)	169 ± 8	169 ± 8	−0.4 (−1.1 to 0.3)
		Peak HR (bpm)	181 ± 8	180 ± 8	0.6 (−2.0 to 0.8)
		% Age-Pred HR_{max} (%)	94 ± 0	94 ± 0	

Note: All values are reported as mean ± SD.
Abbreviations: s, seconds; HR, heart rate; LoA, limits of agreement; bpm, beats per minute; % Age-Pred HR_{max}, percentage of age-predicted maximum heart rate.

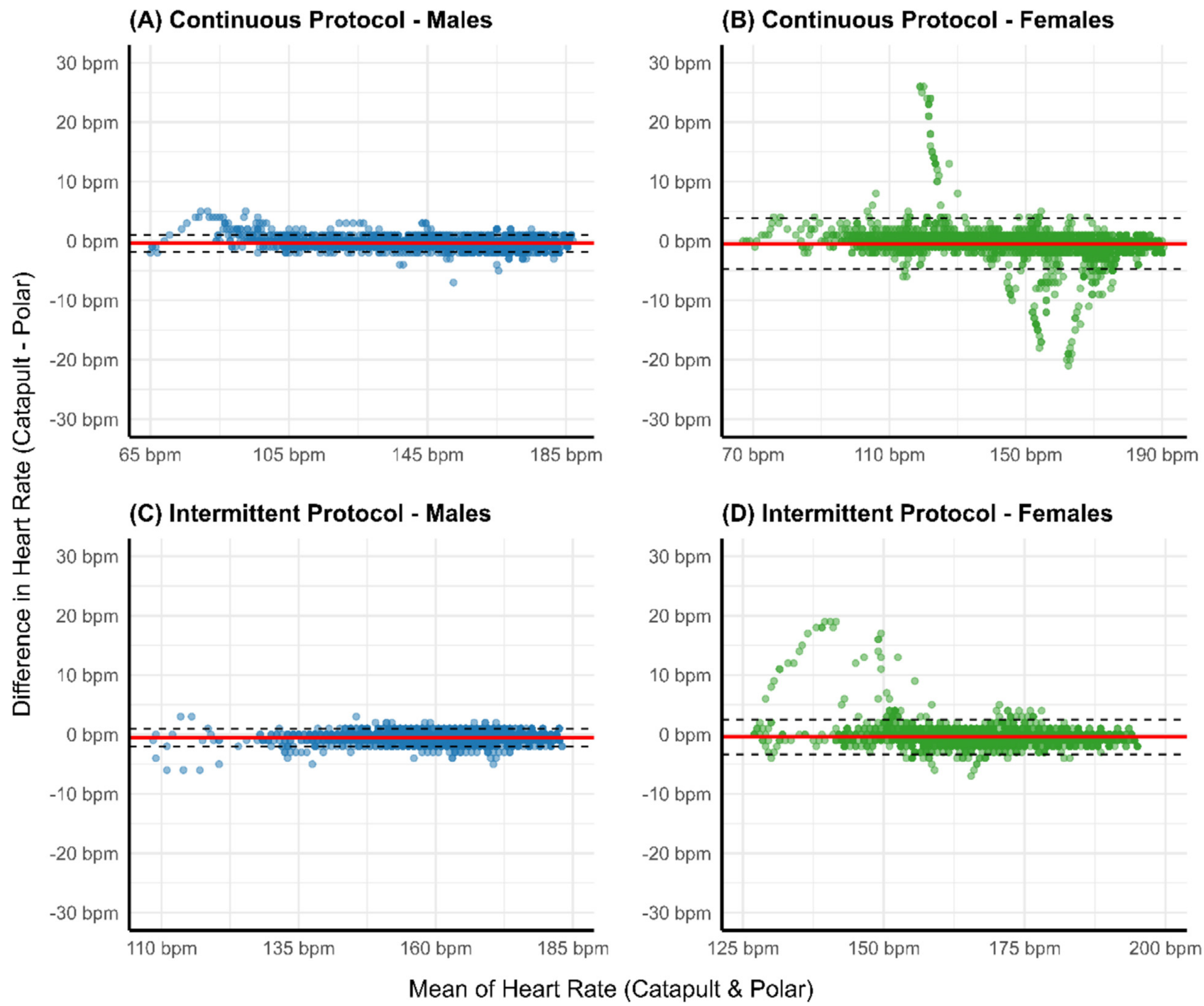

Fig. 2. Bland–Altman plots for all heart rate values during continuous and intermittent protocols. (a) Continuous incremental protocol, males; (b) continuous incremental protocol, females; (c) intermittent protocol, males; (d) intermittent protocol, females. The x-axis shows mean heart rate (Catapult & Polar), and the y-axis shows heart rate difference (Catapult − Polar).

high with R^2 values consistently ≥0.98, RMSE ≤2.2 bpm, and MAPE ≤0.7 %. A small systematic underestimation was observed across all beat-by-beat HR values, with mean bias ranging from −0.4 to −0.5 bpm, and 95 % LoA ranging from −4.8 to 3.8 bpm. Mean bias for average (≤−0.6 bpm) and peak HR (≤−1.0 bpm) was small across both conditions (Table 2). When separated by sex, agreement was

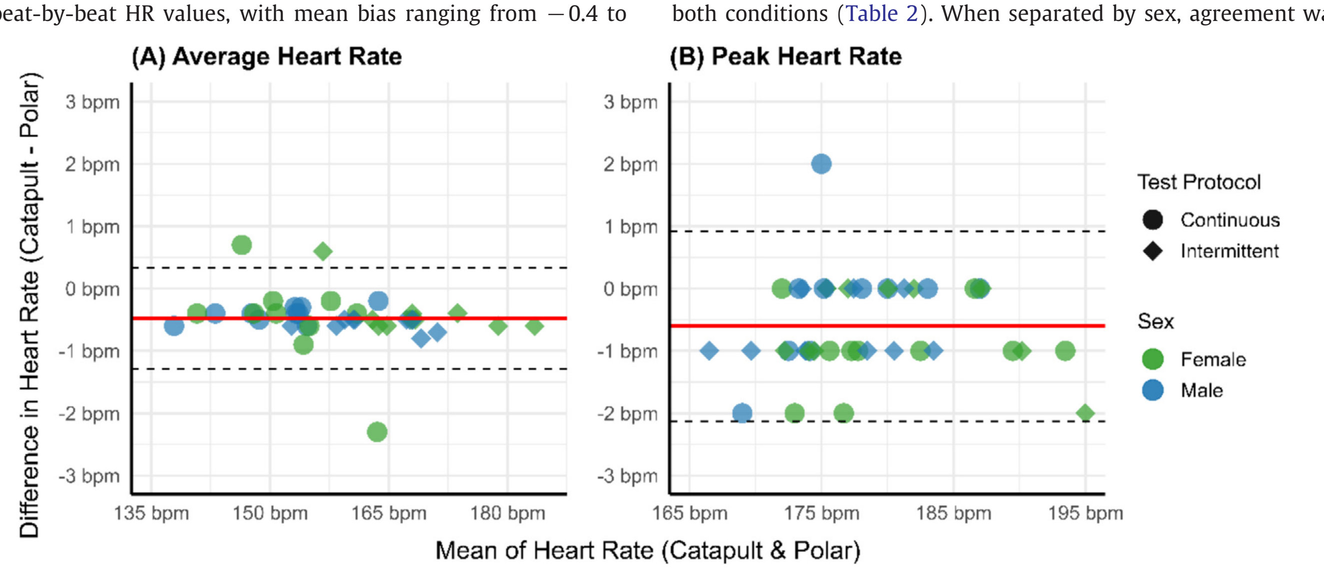

Fig. 3. Bland–Altman plots for (a) average and (b) peak heart rate during continuous and intermittent protocols. The x-axis shows mean heart rate (Catapult & Polar), and the y-axis shows heart rate difference (Catapult − Polar). Sex and test protocol are represented by colour and shape, respectively.

marginally higher in males than females, as reflected by lower RMSE and MAPE values across both running protocols. Nonetheless, in both groups, agreement remained high across continuous and intermittent protocols. Bland–Altman plots for all HR values (Fig. 2), and of average and peak HR (Fig. 3) illustrate the mean bias and associated LoA for all participants.

4. Discussion

The aims of this study were to (1) determine the level of agreement between HR data from the Catapult Vector S7 and Polar H10, and (2) evaluate the concurrent validity of GPS-integrated HR data across different running intensities. The results of this study indicate that the Vector S7, worn within the Vector Elite Vest 2.3, demonstrates near-perfect levels of agreement with the Polar H10 during continuous incremental and intermittent running protocols. Negligible biases were reported for all beat-by-beat HR values (≤0.5 bpm), average HR (≤0.6 bpm) and peak HR (≤1.0 bpm), alongside narrow LoA. Although the LoA for peak HR appear wider compared with average HR, this is expected because peak HR represents a single maximal value, whereas average HR is calculated across a time series, which naturally reduces variability. Additionally, whilst the RMSE and MAPE values were slightly higher in female participants, the Vector S7 remained highly valid, and no systematic bias was observed. Overall, these findings support the use of the Vector S7 in combination with the Vector Elite Vest 2.3 as a valid method for measuring HR during high-intensity exercise involving continuous and intermittent running activity.

To the authors' knowledge, this is the first study to examine the validity of GPS-integrated HR data. Previous research has evaluated wearable HR vests,[11] similar to the Vector Elite Vest 2.3, but using a chest-worn HR device, rather than a GPS device. The Vector S7, as used in the present study has previously demonstrated acceptable validity and reliability for common team sport external load measures, including total distance, total accelerations & decelerations and maximum velocity.[20–22] The present findings enhance the capabilities of the Vector S7; by demonstrating that it can also provide accurate HR measurement during high-intensity exercise involving continuous incremental and intermittent running activity. Previously, capturing HR data alongside external load required a separate chest-worn HR device in addition to a GPS unit. Integrating HR measurement within wearable vests eliminates the need for multiple wearable devices. This minimises athlete and practitioner burden, whilst allowing simultaneous collection of valid internal and external load data via a single wearable device.

Previous validation studies of chest-worn HR devices during high-intensity exercise have largely been conducted under controlled laboratory protocols using cycling[6,9] or treadmill activity.[7,8] The present study adds to the current evidence of wearable HR devices during running activity,[7,8,23] whilst providing novel evidence the Vector S7 accurately measures HR during continuous incremental and intermittent running activities at varying intensities (low-high). Intermittent running activity is a characteristic of many team sports, such as rugby league,[16] Australian rule football[17] and soccer.[18] Whilst the exercise protocols used in present study do not fully replicate all the movement demands of field-based team sports, it was found that the Vector S7 can accurately capture fluctuations in HR during various running activities at low-high intensities, as commonly occurs in these sports. These findings support the use of the Vector S7 for monitoring HR as a measure of internal load in athletes, particularly in team sports characterised by intermittent running activity, whilst advising practitioners to carefully check HR data quality during contact-based activities, as device validity in these contexts remains unexplored.

Wearable HR devices like the Vector S7 or Polar H10 are commonly implemented in team sport settings. Their use is largely supported by recommendations of an integrated training load monitoring approach, which captures internal and external load to accurately quantify athlete training loads.[24–26] As a result, these devices are frequently employed in team sport training and competition, not only to capture athletes' physiological responses to exercise, but also to contextualise HR responses alongside external load measures such as distance covered, acceleration & deceleration, and PlayerLoad™.[27–29] The results of the present study demonstrated that the Vector S7 provided accurate HR measurements across all physiological exercise intensities, as shown by the Bland–Altman plot in Fig. 2, thereby supporting its use as a practical tool for monitoring both internal and external loads in team sport athletes.

When examining the Bland–Altman plots, particularly the beat-by-beat HR data in Fig. 2, a small number of data points fall outside the LoA, indicating that outliers may be present in the dataset. For the purposes of this analysis, all HR values were included in the final dataset, as in applied practice, these outlier measurements are still recorded by the wearable device and removing them would not reflect the true accuracy of the devices used in this study. In research, common approaches to identify outliers include excluding HR values that occur outside the interquartile range[30] or exceed standard deviation thresholds.[31] However, applying these methods requires expertise and resources, and without it, inaccurate HR values may go unnoticed in practice. This could lead to a misrepresentation of an athlete's physiological responses to exercise and impact the ability for practitioners to accurately monitor training loads and optimise training outcomes. For example, outlier HR values could misrepresent time spent in specific HR zones, which are used to monitor internal loads of athletes,[27,32] by falsely inflating or deflating time in certain zones, and providing inaccurate measurements of training load. Manufacturers of wearable HR devices should improve outlier detection and data filtering processes, reducing the likelihood of inaccurate values being reported in practice. Practitioners must also ensure that athletes strictly follow manufacturer vest garment sizing guidelines, as an improperly fitting vest can compromise electrode contact and ultimately reduce HR data accuracy.

One factor that may influence HR data accuracy, yet remains largely unexplored in the literature is the influence of physical contact (e.g., the influence of tackling or grappling) on wearable HR devices. To date, validation protocols, including those employed in the present study, have predominantly used controlled locomotor activities, which do not fully replicate the contact demands of team sports.[7,8,23] Whilst incorporating contact-based movements may enhance the ecological validity of wearable HR research, such activities increase the risk of the chest strap moving or dislodging and introducing data artefacts, making it difficult to determine whether observed differences reflect device limitations or introduced by factors not related to the accuracy of the device to collect HR. In applied settings, wearable HR devices can still be implemented to monitor athlete training loads in contact-based team sports; however, practitioners should implement procedures to identify potential device displacement beyond locomotor activity. Importantly, the mechanism underlying such measurement error stems from the movement pattern itself rather than the device's ability to measure HR. Provided that direct skin–electrode contact is maintained, the present findings indicate that the Vector S7 delivers accurate HR data across all intensities and exercise modes.

The present study also provides novel data on the sex-related accuracy of the Vector S7, an area which has largely been overlooked in previous validations of chest-worn HR devices. Of previous studies, one did not include female participants,[8] another included only two females,[33] and none examined the potential influence of sex-related factors (e.g., interactions with additional items of clothing) on HR measurement accuracy.[7–9,23,33] In the present study, the Vector S7 demonstrated high validity during continuous and intermittent running, with slightly poorer, but practically negligible accuracy compared to males (RMSE ~ 1 bpm). For the female participants in this study, a sports bra was worn over the vest and Polar strap, which could have potentially affected data quality. Whilst no systematic impact on data quality was observed, the slightly poorer agreement may have resulted from altered vest fit and electrode positioning, where the additional garment may have introduced variability or signal noise that influenced HR detection. Another sex-related factor, particularly prevalent in females, is breast biomechanics which could introduce subtle variability in HR measurements.[34] During high-intensity exercise the movement and displacement of breast tissue can alter electrode-skin contact and overall vest fit, potentially affecting overall HR signal quality.[34] However, it must be noted that the Vector Elite Vest 2.3 used in the present study is not specifically designed for females, highlighting the need for future advancements in female-specific vest design. A potential solution could involve the development of female-specific sports bras that integrate ECG-based HR sensors and pouches at the back of the sports bra for the GPS unit.

The primary limitation of this study is the use of the Vector Elite Vest 2.3 in addition to the Polar H10 chest strap resulted in the Polar device being positioned slightly lower than recommended by the manufacturer. However, the results suggest that this did not affect data quality in either device. Another limitation is the protocols used in this study involved continuous incremental and intermittent treadmill running, which do not fully reflect the movement patterns and contact elements of team sports, particularly collision-based sports. Future research should seek to determine the validity of the Vector S7 to accurately measure HR during common team sport movements; however, incorporating contact-based drills such as tackling or wrestling risks dislodging the chest strap and introducing artefacts that confound interpretation. Additionally, as no chest-strap device has been specifically validated under contact conditions, such approaches present inherent limitations to such an investigation. Finally, it is important for practitioners and researchers to note that the impact of regular washing on vest-embedded electrodes is unknown, and it is unclear whether this could affect HR data quality. The vests used in this study were brand new and had not been worn before, whereas in practice these vests are recommended to be machine-washed after each use. Repeated washing may degrade the ECG signal quality, and over time could cause partial detachment or loosening of the sensors from the vest, leading to variable sensor contact and reduced data accuracy. Therefore, future research should investigate this area to determine if regular washing affects the data quality of GPS-integrated HR.

5. Conclusion

The Catapult Vector S7, when used in combination with the Vector Elite Vest 2.3 is a valid approach to accurately measure HR during continuous incremental and intermittent running. This integration demonstrated near-perfect agreement and minimal bias for both running protocols. The GPS-integrated HR data were slightly more accurate in male participants; however, the difference was practically negligible, and the measurements remained highly valid. Practitioners can confidently use the combination of the Vector S7 and Vector Elite Vest 2.3 to accurately measure HR, thereby providing valuable insights into an athlete's physiological response to exercise, whilst appropriately considering data accuracy during contact-based activities. Consequently, the Vector S7 can be considered an appropriate alternative to chest-worn HR devices, providing practitioners with a practical and efficient approach to monitor athlete training loads via a single wearable device.

CRediT authorship contribution statement

Thomas Fary: Conceptualisation, methodology, data collection, analysis and writing of the manuscript. **Rich Johnston:** Conceptualisation, methodology, analysis and manuscript review. **Grant Duthie and Patrick Campbell:** Conceptualisation, methodology and manuscript review. **Jacob Jennings:** Conceptualisation and manuscript review. **David Ballard and Michael Speranza:** Manuscript review.

Confirmation of ethical compliance

All procedures in this study were approved by the Australian Catholic University Human Research Ethics Committee (2024-3831H).

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Declaration of interest statement

The authors declare that they have no financial or other interest in the products used in this study.

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