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THE VALIDITY AND INTER-UNIT RELIABILITY OF CUSTOM-MADE SURFTRAX GPS UNITS AND USE DURING SURFING

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Purpose

The purposes of the study were to: i) gain further understanding of the movement patterns during surfing using custom made GPS units which are designed for surfing (SurfTraX, Gold Coast, Australia), and ii) determine the validity and inter-unit reliability of the these units.

Methods

- **Experimental Approach**

To gain a better understanding of the external loads of surfing, 10 surfers during competition had a GPS unit recording data (10Hz), positioned under their wetsuit on upper vertebrae. To determine validity and inter-unit reliability, nine GPS units were used during three specific tests, with units positioned across and taped down to the upper-back of two subjects. Tests consisted of a 100m sprint (similar to wave speeds), running between points in a 'W' shaped course (replicate bottom and top turns on a wave), and walking around a rugby field, making sharp rotation at each corner (replicate paddling and turns). Validity was determined by comparing GPS distance and actual tape measured. Inter-unit reliability was determined by comparing distance covered, peak velocity, and time to cover distance from 20 (subject one) and 25 (subject two) data sets.

- **Statistical Analysis**

Descriptive statistics were calculated for all variables and reported as mean ± SD (and range). Paired sample t-tests were used for GPS validity by determining the differences between actual test distance and GPS unit recordings, as well as comparisons between all units using SPSS (Version 22.0; Chicago, IL) with statistical significance at $p \leq 0.05$. The inter-unit reliability was determined using Hopkins's reliability spreadsheet to calculate the percentage of typical error of measurement (%TEM), and the intraclass correlation coefficient (ICC). The magnitudes of %TEM used included poor (≥10%), moderate (5–10%), or good (≤5%). Strength of ICC scores was based on Pearson correlation scores system involving trivial (0.0), small (0.1), moderate (0.3), large (0.5), very large (0.7), nearly perfect (0.9), and perfect (1.0). Effect size (*r*) was used (<0.2 = trivial, 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 = large, and >2.0 = very large) in determining difference between measured distance and GPS distance.

Results

- **Surfing**

Surfers travelled a total distance (including all movements such as paddling, and wave riding) of 997m (range; 628m – 1678m) per 20 min heat, at an average speed of 16.7 km/h per wave, with peak wave ridings speeds approximately 25.2km/h (19 – 31km/h). The maximal distance covered during a wave was 132m (82m – 180m).

- **GPS Validity**

Validity was determined from 12 sets of data over the courses. No significant difference were reported between actual distance of the 100m sprint (101.1 ± 4.46m, $p = .422$, t = .834), W course (28.4m) (28.58 ± 5.65, $p = .913$, t = .112) and the walk (336m) (334.6 ± 7.80, $p = .636$, t = -.494). Furthermore, no significant difference were reported between all GPS units measures (100m sprint, $p = .987$, t = -.017), (W course, $p = .100$, t = -1.814), (Walk $p = .180$, t = 1.491). Effect size between actual measures and that of all GPS recordings ($n = 45$) were r = 0.5 for the walk, r = 0.3 for W run and r = 0.7 for 100m sprint.

- **GPS Inter-unit Reliability**

All inter-unit reliability results are reported in Tables 1 and 2 for the two subjects performing the tests over the two days.

Table 1: Raw data are presented with mean ±SD from subject one using GPS units 1 – 4. *Set 1 and 2 on day 1; Sets 3 – 5 on day 2

Variable	Set 1	Set 2	Set 3	Set 4	Set 5	ICC	%TEM
Peak Speed (km/h)							
100m	26.5 ± 0.45	29.2 ± 0.45	29.0 ± 0.47	27.5 ± 0.36	29.3 ± 0.52	**0.94**	**0.95**
W run	14.7 ± 0.26	14.3 ± 0.37	13.5 ± 1.22	13.5 ± 1.02	13.9 ± 0.78	**0.90**	**1.85**
Walk (mean)	5.2 ± 0.05		4.7 ± 0.06	4.5 ± 0.06		**1.00**	**0.55**
Distance (m)							
100m	109.2 ± 1.55	115.3± 1.38	99.15 ± 3.66	104.2 ± 5.29	99.8 ± 0.24	**0.71**	**1.60**
W run	32.3 ± 2.51	27.9 ± 0.58	31.35 ± 9.71	26.9 ± 2.14	27.5 ± 1.65	**0.23**	**9.50**
Walk	377.7 ± 2.85		336.4 ± 7.47	332.8 ± 8.80		**0.87**	**0.70**
Time (s)							
100m	16.5 ± 0.30	15.3 ± 0.21	14.0 ± 0.17	14.8 ± 0.10	13.9 ± 0.24	**0.78**	**1.35**
W run	8.5 ± 0.45	8.2 ± 0.32	7.6 ± 1.51	8.6 ± 0.15	8.6 ± 0.25	**0.74**	**6.60**
Walk	235.5 ± 0.58		260.2 ± 0.13	273.3 ± 0.27		**0.98**	**0.10**

Table 2: Raw data are presented with mean ± SD from subject two using GPS units 5 – 9. *Set 1 and 2 on day 1; Sets 3 – 5 on day 2

Variable	Set 1	Set 2	Set 3	Set 4	Set 5	ICC	%TEM
Peak Speed (km/h)							
100m	28.6 ± 0.22	31.0 ± 0.13	31.6 ± 0.65	29.9 ± 0.59	29.7 ± 0.58	**0.78**	**0.85**
W run	14.3 ± 1.04	14.9 ± 0.96	11.7 ± 0.85	11.8 ± 1.37	12.3 ± 1.21	**0.30**	**4.22**
Walk (mean)	5.1 ± 0.15		4.4 ± 0.65	4.2 ± 0.19		**0.69**	**1.50**
Distance (m)							
100m	110.3 ± 3.26	113.3 ± 1.05	100.2 ± 0.15	106.6 ± 4.27	99.1 ± 1.55	**0.43**	**2.40**
W run	34.3 ± 2.83	32.1 ± 2.87	25.3 ± 0.53	26.4 ± 2.49	26.4 ± 2.49	**0.16**	**6.95**
Walk	366.6 ± 28.74		326.7 ± 19.33	427.4 ± 34.31		**0.92**	**1.80**
Time (s)							
100m	16.1 ± 0.38	15.6 ± 0.10	12.9 ± 0.44	13.9 ± 0.36	13.9 ± 0.36	**0.80**	**2.00**
W run	9.7 ± 0.71	9.3 ± 0.47	8.0 ± 1.35	8.7 ± 0.54	7.9 ± 0.48	**0.81**	**6.15**
Walk	211.5 ± 28.74		254.5 ± 8.24	272.2 ± 1.02		**0.18**	**2.20**

Conclusions

- The validity of the GPS units demonstrated valid measures with no significant differences being reported between measures (Small (≤0.6) and moderate (0.7) effect size (*r*) between 45 GPS recordings do indicate slight difference). The inter-unit reliability revealed good levels of repeatability when measuring the peak speed per test (0.55 – 4.22%). Likewise, distance and times recorded for the 100m sprint and the walk also had good levels of repeatability (0.10 – 2.40%). The 'W' course measures were reported to have moderate levels of repeatability for distance and time (6.15 – 9.50%).
- The application of GPS during surfing has provided valid insights of the sport and is a simple piece of technology to place under the wetsuit to gather important performance data, which is useful in designing training programs and testing protocols. The activities associated with surfing should be interpreted with caution, particularly peak velocities and distance travelled while surfing on a wave, as surfers are often riding horizontally along the wave, and going from the top to the bottom of the wave. GPS units record changes in horizontal direction; therefore wave riding at speed and turning (≥20km/h) are likely to be slightly overestimated, with total distances at low speed (≤10km/h) potentially underestimated.