TRACKING THROUGH ULTRA WIDE BAND TECH

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Area of sport performance FCB
(Tracking monitoring)

TRACKING HISTORY IN FCB

TEAMWORK

OUTDOOR vs INDOOR

VALIDITY & RELIABILITY

FCB VIEW

TRACKING MONITORING HISTORY IN FCB

Beginnings

- 1st Soccer team just with few devices

Soccer teams

- Added until U17

Indoor tracking

- All 1st teams begins to track their players

Unique system

- Indoor teamwork

Actually: Tracking monitoring TEAMWORK

All the club with the same company, but not the same location system

TEAMWORK

Outdoor sports

- 1st Soccer team (M)
- 1st Soccer team (F)
- 2nd Soccer team (M)
- U18 Soccer team (M)
- U17 Soccer team (M)
- U16 Soccer team (M)
- Youth Soccer academy (M)

Indoor sports

- 1st Basketball team (M)
- 1st Handball team (M)
- 1st Futsal team (M)
- 1st Roller hockey team (M)
- 2nd Basketball team (M)

TEAMWORK

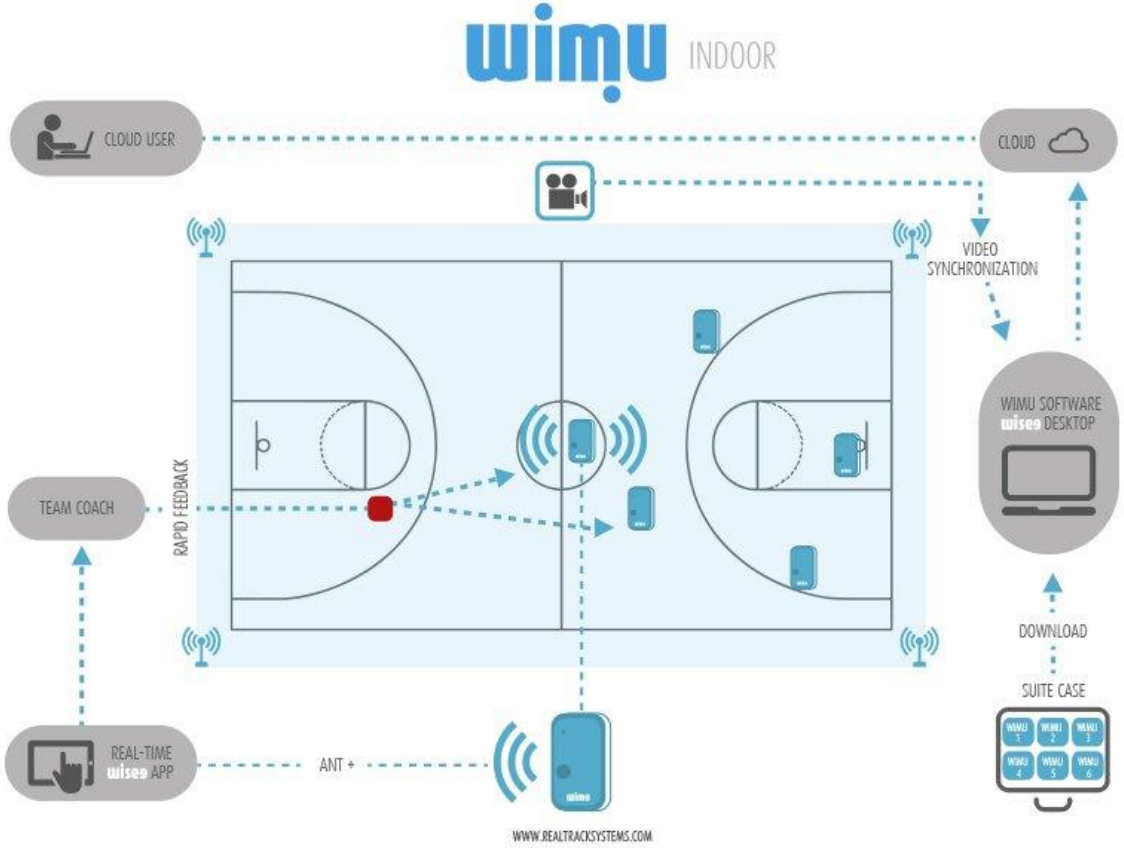
REALTRACK systems

TEAMWORK

WIMU PRO

DOCK STATION

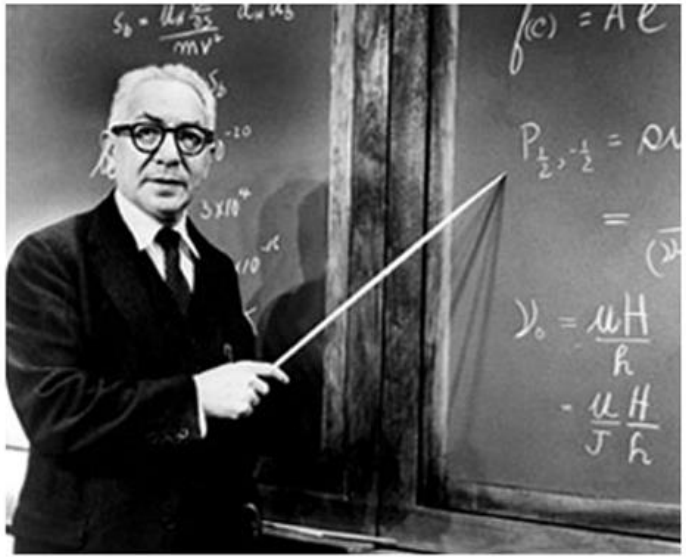
TEAWORK


wimu INDOOR
CLOUD USER
CLOUD
VIDEO SYNCHRONIZATION
WIMU SOFTWARE wiseo DESKTOP
TEAM COACH
RAPID FEEDBACK
DOWNLOAD
SUITE CASE
REAL-TIME wiseo APP
ANT +
WWW.REALTRACKSYSTEMS.COM

OUTDOOR VS INDOOR

- 1944: **Isidor Isaac Rabi Nobel** laureate in **physics.**

Invented the magnetic resonance, lead to the creation of the **Atomic clock**, the **precise time pieces** that form the **basis of satellite navigation**

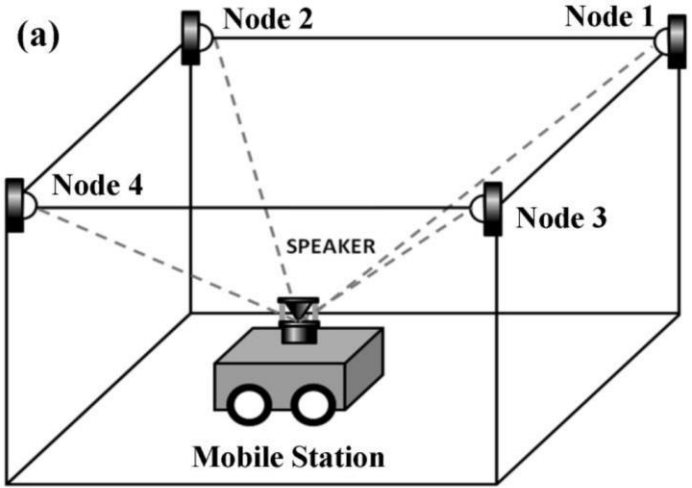


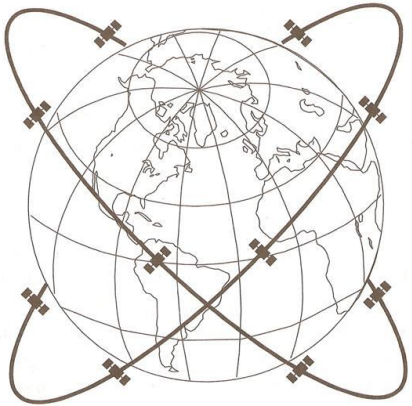
OUTDOOR VS INDOOR

- The precise measurement of atomic clock -> **calculation of the length of time it takes a radio signal** to travel from satellite GPS receiver on earth

OUTDOOR VS INDOOR

What’s the difference?





LPS

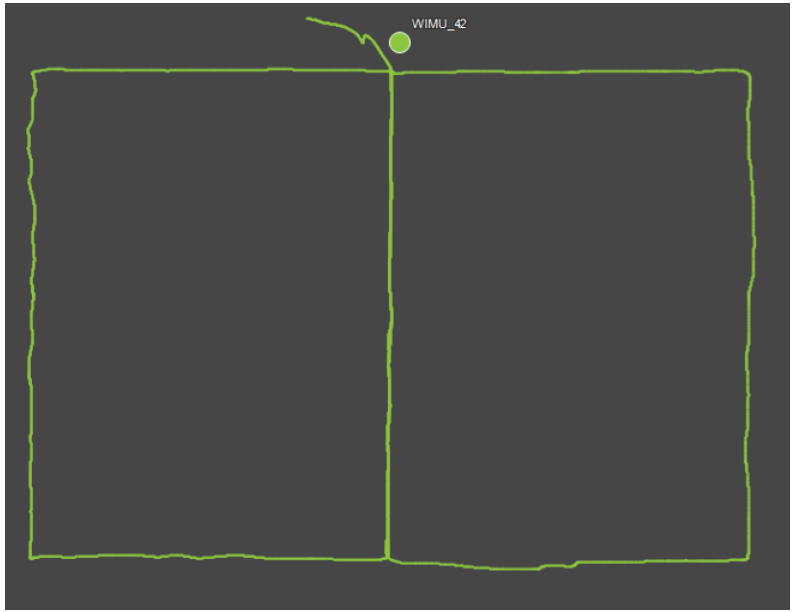
Local Positioning System

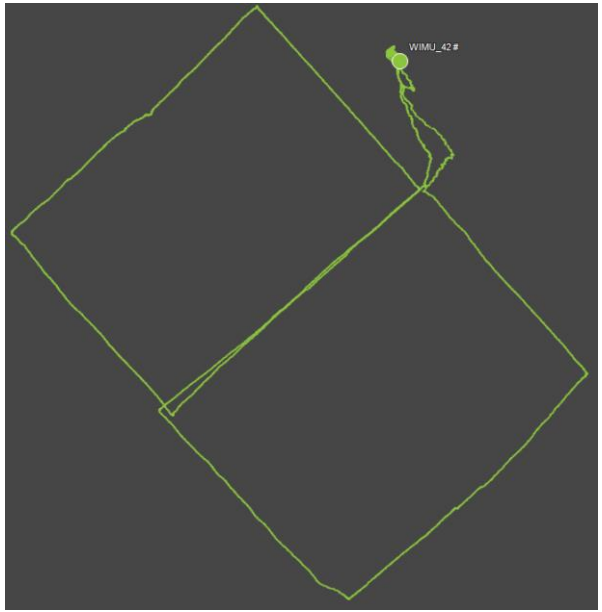
vs

GPS/GNSS

Global Positioning System

OUTDOOR VS INDOOR





LPS vs GPS/GNSS

OUTDOOR vs INDOOR

There ISN’T ONLY Positioning…

DATA POSITIONING DERIVED

- **Position (x,y)**
- Distance
- Velocity
- Acceleration

DATA INERTIAL SENSORS DERIVED

- Accelerations
- Angular movement & speed
- Elevation
- ANT+ devices connected
- …

Don’t need positioning!!!

VALIDITY & RELIABILITY

Not valid
Not reliable

Low validity
Low reliability

Not validity
Reliable

Valid
Reliable

VALIDITY & RELIABILITY

Table 1. The validity measurements of all studies published to date.*

Reference	GPS device	Sampling rate	Parameter	Task	Criterion measure	Error measurement	Interpretation
Edgecomb and Norton (13)	SPI 10	1 Hz	Total distance	Marked circuit running; (138–1,386 m)	Trundle wheel pedometer	Average total distance error: 4.8%†	Good
Gary et al. (16)	WiSPI elite	1 Hz	Total distance	Linear and nonlinear running (200 m)	EDM/theodolite	Linear: 1.8–5.8m; nonlinear: −1.1 to −19.6m	
Coutts and Duffield (8)	SPI 10, SPI elite, WiSPI	1 Hz	Total distance	Running circuit; (128.5 m)	Measuring tape	Total distance error: 0.7–4.1%	Good
MacLeod et al. (26)	SPI elite	1 Hz	Total distance	Hockey simulated circuit; (including 4 shuttle runs)	Trundle wheel pedometer	Total distance: 2.5m; 4 shuttles: ±0.2 m†	
			Speed		Timing gates	Only speed during straight-line sprint shuttle was significantly different ($p < 0.01$)	
Barbero-Alvarez et al. (4)	SPI elite	1 Hz	Speed	30 m sprint	Infrared light sensors	Total sprint time: $r^2 = -0.96$, $p < 0.001$; fastest sprint time: $r^2 = -0.93$, $p < 0.001$	
Petersen et al. (30)	SPI 10	1 Hz	Total distance	Cricket-specific running; (600–8,800 m)	Athletics track	SEE: 0.6–2.1%	Good
	SPI-Pro	5 Hz				SEE: 0.4–3.7%	Good
	MinimaxX	5 Hz				SEE: 1.7–3.8%	Good
	SPI-Pro	5 Hz		Sprint trials; (20–40 m, run-a-three)	Timing gates	SEE: 5.5–10.5%	Good-moderate
	MinimaxX	5 Hz				SEE: 5.3–23.8%	Good-poor
Jennings et al. (20)	MinimaxX team 2.5	1 Hz	Total distance	Sprint trials; (10–40 m, 20–40 m interval)	Timing gates	SEE: 9.6–32.4%	Moderate-poor
		5 Hz				SEE: 9.0–30.9%	Moderate-poor
		1 Hz		Tight change of direction; (40 m)	Measuring tape and goniometer	SEE: 9.0–12.6%	Moderate-poor
		5 Hz				SEE: 9.9–11.5%	Moderate-poor
		1 Hz		Gradual change of direction; (40 m)	Measuring tape and goniometer	SEE: 9.1–12.7%	Moderate-poor
		5 Hz				SEE: 8.9–11.7%	Moderate-poor
		1 Hz		Team sport simulated circuit; (140 m)	Measuring tape	SEE: 3.6%	Good
		5 Hz				SEE: 3.8%	Good

(continued on next page)

(Scott, Scott & Kelly, 2016)

VALIDITY & RELIABILITY

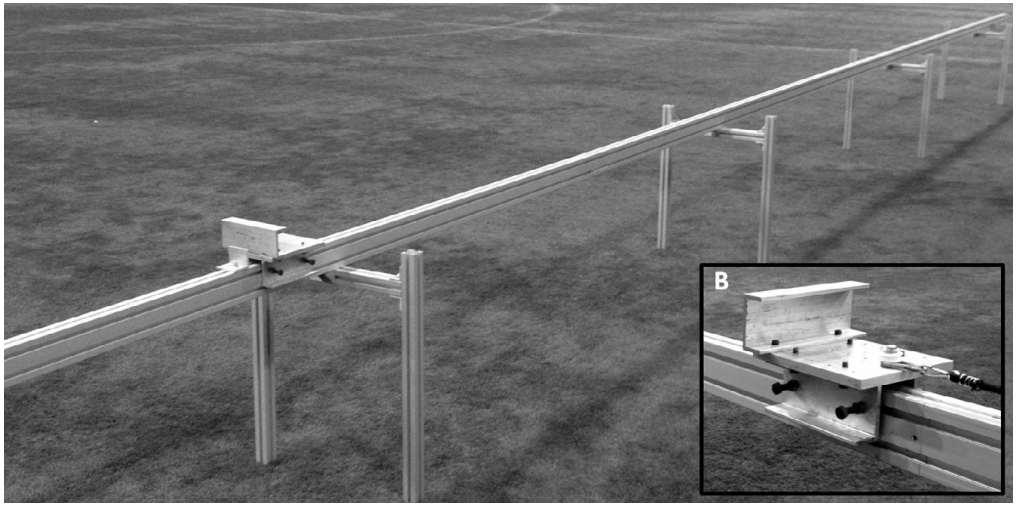
Portas et al. (31)	MinimaxX v2.5	1 Hz	Total distance	Linear course	Trundle wheel pedometer	SEE: 2.6–2.7%	Good
		5 Hz				SEE: 2.9–3.1%	Good
		1 Hz		Multidirectional course		SEE: 1.8–6.8%	Good-moderate
		5 Hz				SEE: 2.2–4.4%	Good
		1 Hz		Soccer-specific course		SEE: 1.3–3.0%	Good
		5 Hz				SEE: 1.5–2.2%	Good
Waldron et al. (37)	SPI-Pro	5 Hz	Total distance	Sprint; (10–30 m, moving 10 m)	Tape measure	CV: 4.81–8.09%	Good-moderate
			Speed		Timing gate	CV: 5.68–9.81%	Moderate
Johnston et al. (23)	MinimaxX team 2.5	5 Hz	Total distance	Team sport simulated circuit; (130.5 m)	Tape measure	No significant difference to criterion	
			Peak speed (average)		Timing lights	No significant difference to criterion	
			Peak speed (instantaneous)	Flying 50 m efforts	Radar gun	No significant difference to criterion	
Rampinini et al. (32)	SPI-Pro	5 Hz	Total distance	70 m straight-line shuttle runs	Radar gun	CV: 2.8%	Good
	MinimaxX v4.0	10 Hz				CV: 1.9%	Good
	SPI-Pro	5 Hz	HSR distance			CV: 7.5%	Moderate
	MinimaxX v4.0	10 Hz				CV: 4.7%	Good
	SPI-Pro	5 Hz	VHSR distance			CV: 23.2%	Poor
	MinimaxX v4.0	10 Hz				CV: 10.5%	Poor
Varley et al. (35)	MinimaxX v2.0	5 Hz	Instantaneous velocity	Straight-line running	Laveg laser	CV: 3.6–11.1%	Good-poor
						Acceleration CV: 7.1–14.9%	Moderate-poor
						Deceleration CV: 33.2%	Poor
	MinimaxX v4.0	10 Hz				Constant velocity (CV): 3.1–8.3%	Good-moderate
						Acceleration CV: 3.6–5.9%	Good-moderate
						Deceleration CV: 11.3%	Poor
Castellano et al. (7)	MinimaxX v4.0	10 Hz	Total distance	15m sprints	Tape measure	SEM: 3.8–9.6% (mean: 10.9%)	Good-moderate
				30 m sprints		SEM: 1.7–6.7% (mean: 5.1%)	Good-moderate
Akenhead et al. (1)	MinimaxX S4	10 Hz	Instantaneous velocity	10 m sprint	Laser	SEE: 0.12–0.32 $m \cdot s^{-1}$; (all data SEE: 0.19 $m \cdot s^{-1}$)	

(Scott, Scott & Kelly, 2016)

VALIDITY & RELIABILITY

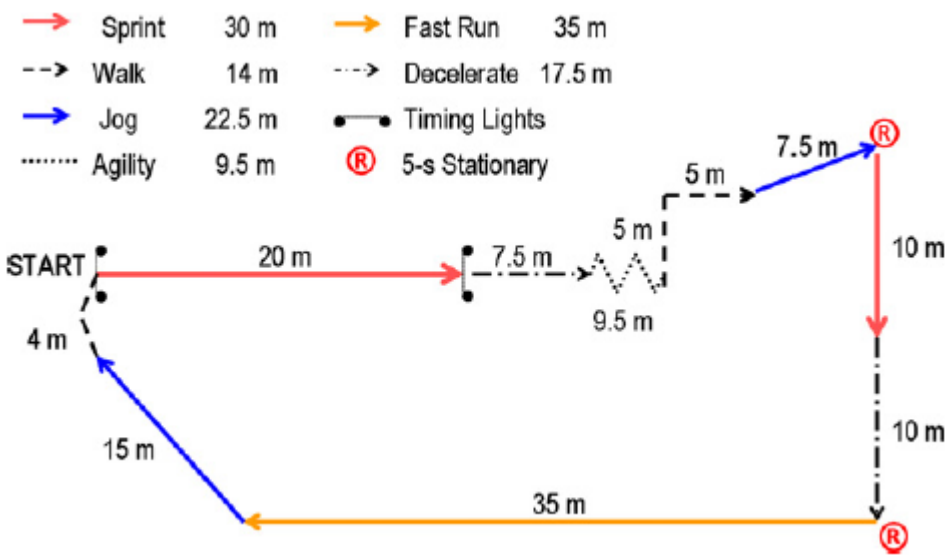
"The validity and inter-unit reliability of 10 Hz GPS for the measurement of instantaneous velocity has been shown to be inversely related to acceleration"

(Akenhead, et al., 2013)



VALIDITY & RELIABILITY

"Poor level of intra-model reliability for very high intensity running"

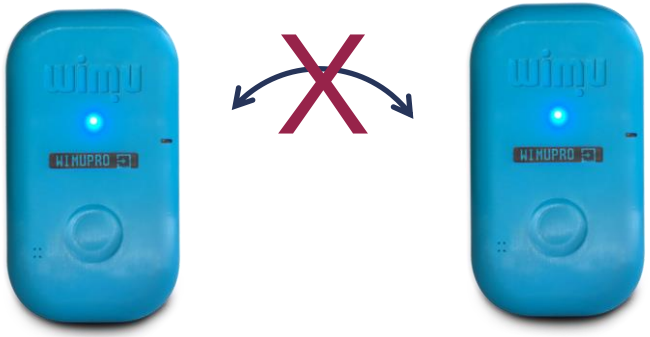


(Coutts & Duffield, 2008)

VALIDITY & RELIABILITY

“To eliminate inter-unit variation, GPS devices should not be used interchangeably”

(Akenhead, et al., 2013)



Player A

Player B

VALIDITY & RELIABILITY

- 1 to 5 Hz GPS have limitations during short distance.
- 10 Hz GPS seems to be the better frequency with no difference with 15 Hz.
- But, few studies with 15 Hz that can explain that

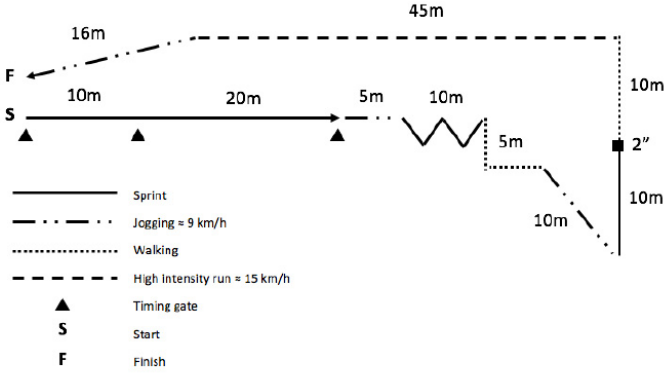
(Scott, Scott & Kelly, 2016)

VALIDITY & RELIABILITY

The validity and reliability of a 5-hz GPS device for quantifying athletes' sprints and movement demands specific to team sports

ALEJANDRO MUÑOZ-LOPEZ [1], PAULINO GRANERO-GIL[2], JOSE PINO-ORTEGA[3], MOISES DE HOYO[4]

CIRCUIT - A



CIRCUIT - B

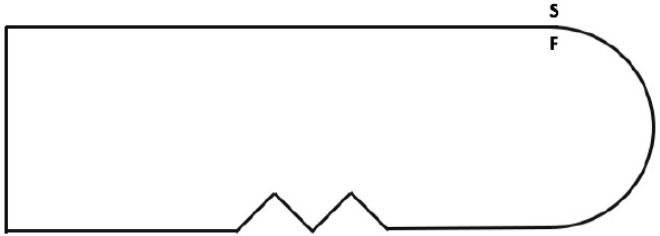


Figure 1 Caption. Circuits used for the study. Circuit-A was performed by athletes with 1 GPS at the same time. Circuit-B was performed by a golf cart with 8 GPS at the same time.

VALIDITY & RELIABILITY

Table 1. Validity study results for Circuit A, 10m and 30m sprints. The Peak-Speed was used to detect if there were high-speed movements. ES = effect size. LOA = Bland-Altman limits of agreement.

Distance	Criterion (m ± sd)	WIMU (m ± sd)	Peak speed ($km \cdot h^{-1}$ ± sd)	BIAS (m)	p-value	ES	95% LOA
Circuit	146 ± 0	143.27 ± 1.64	29.02 ± 6.69	-2.73 ± 1.64	0.000	2,35	-5.94 ; -0.48
10 m	10 ± 0	9.20 ± 0.58	22.13 ± 7.21	-0.80 ± 0.58	0.000	1,95	-1.93 ; 0.35
30 m	30 ± 0	30.42 ± 2.50	28.99 ± 9.40	0.42 ± 2.5	0.515	-0,23	-4.48 ; 5.32

(Muñoz-López et al., 2017)

VALIDITY & RELIABILITY

Table 2. Circuit B and motorized sprints GPS Speed inter-unit reliability results. ICC = intraclass correlation coefficient. CI = confidence interval.

	Circuit			Motorized sprints		
	N	ICC	CI 95%	N	ICC	CI 95%
Lap 1	384	0.977	0.980-0.973	25	0.996	0.993-0.998
Lap 2	344	0.986	0.984-0.988	23	0.985	0.973-0.992
Lap 3	348	0.986	0.984-0.988	26	0.992	0.987-0.996
Lap 4	339	0.982	0.979-0.985	22	0.990	0.982-0.995
Lap 5	339	0.971	0.966-0.975	23	0.990	0.982-0.995
Lap 6	335	0.950	0.942-0.957	23	0.992	0.987-0.996
Lap 7	332	0.974	0.969-0.978	24	0.994	0.990-0.997
Lap 8	337	0.983	0.980-0.985	24	0.992	0.987-0.996

(Muñoz-López et al., 2017)

VALIDITY & RELIABILITY

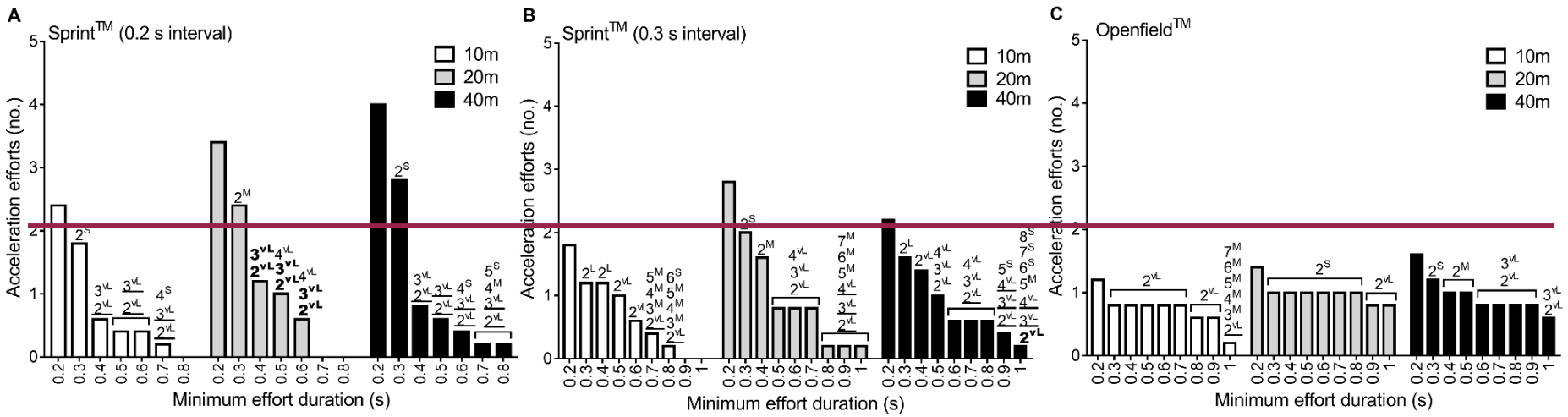
Table 3. Circuit A, 10m sprints and 30m sprints intra-unit reliability results. LOA = Bland-Altmant limits of agreement.

	Circuit A		10m Sprints		30m Sprints	
Outcomes	Mean ± SD	95% LOA	Mean ± SD	95% LOA	Mean ± SD	95% LOA
TD	0.00 ± 1.68	-3.29 ; 3.29	0.00 ± 0.49	-0.96 ; 0.96	0.00 ± 2.34	-4.59 ; 4.59
Peak-Speed	0.00 ± 0.73	-1.43 ; 1.43	0.00 ± 0.53	-1.04 ; 1.04	0.00 ± 0.76	-1.49 ; 1.49
Avg-Speed	0.00 ± 0.33	-0.65 ; 0.65	0.00 ± 0.77	-1.51 ; 1.51	0.00 ± 0.74	-1.45 ; 1.45

(Muñoz-López et al., 2017)

VALIDITY & RELIABILITY

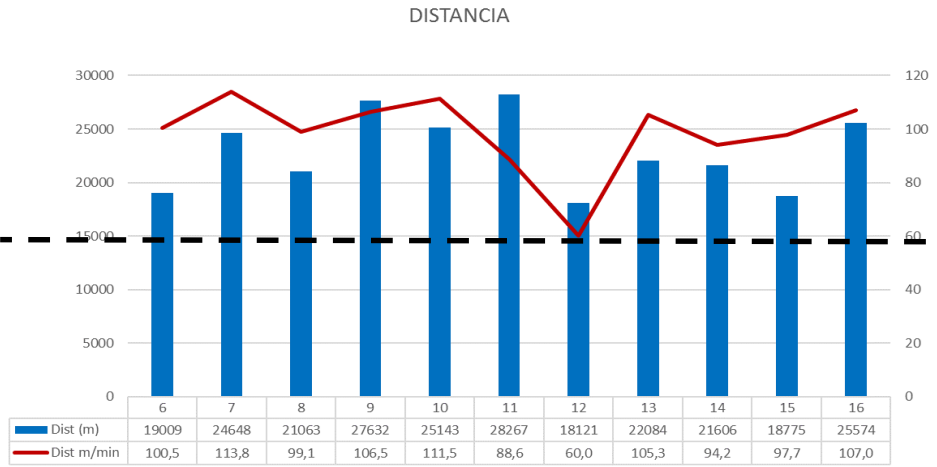
The world of filtering method

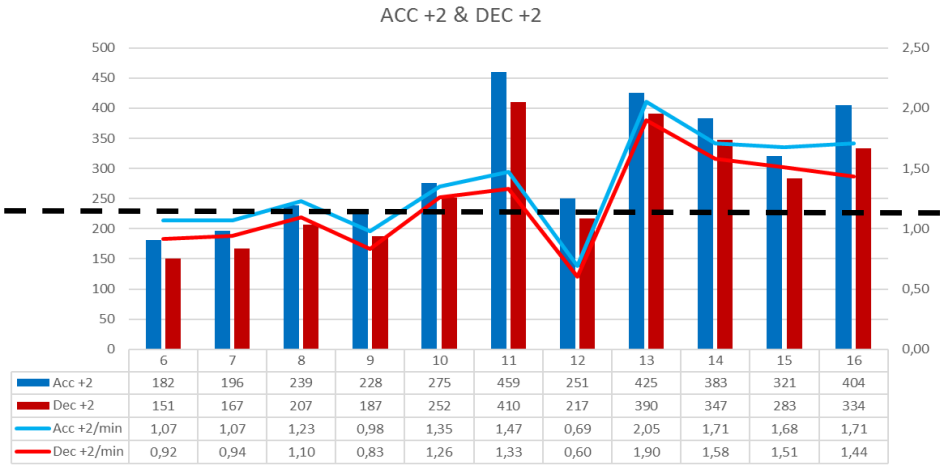


(Vareley, et al., 2017)

VALIDITY & RELIABILITY

The world of filtering method





(Unpublished data)

VALIDITY & RELIABILITY

Ultra Wide Band acuracy

ACCURACY AND INTER-UNIT RELIABILITY OF ULTRA WAVE BAND TRACKING SYSTEM (WIMU PRO™) IN INDOOR CONDITIONS

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(Unpublished data)

VALIDITY & RELIABILITY

Ultra Wide Band acuracy

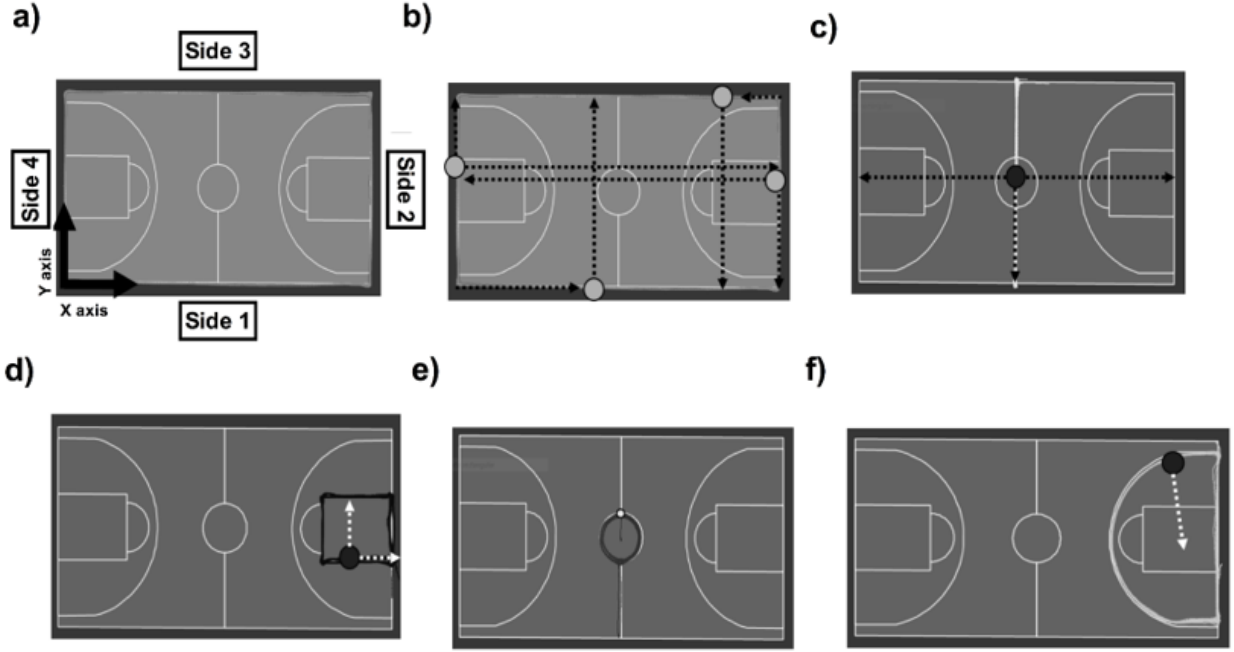


Figure 3. (a) Arrangement of sides and axes for the analysis of the movements made by basketball players in this investigation and design of the different travels carried out in this research: (b) perimeter of court course; (c) middle line court; (d) perimeter of the paint; (e) center circle and (f) 6,75 line.

(Unpublished data)

VALIDITY & RELIABILITY

Ultra Wide Band acuracy

Table 1. *Accuracy in differences (in centimetres) and percentage of differences of "x" and "y" position coordinates.*

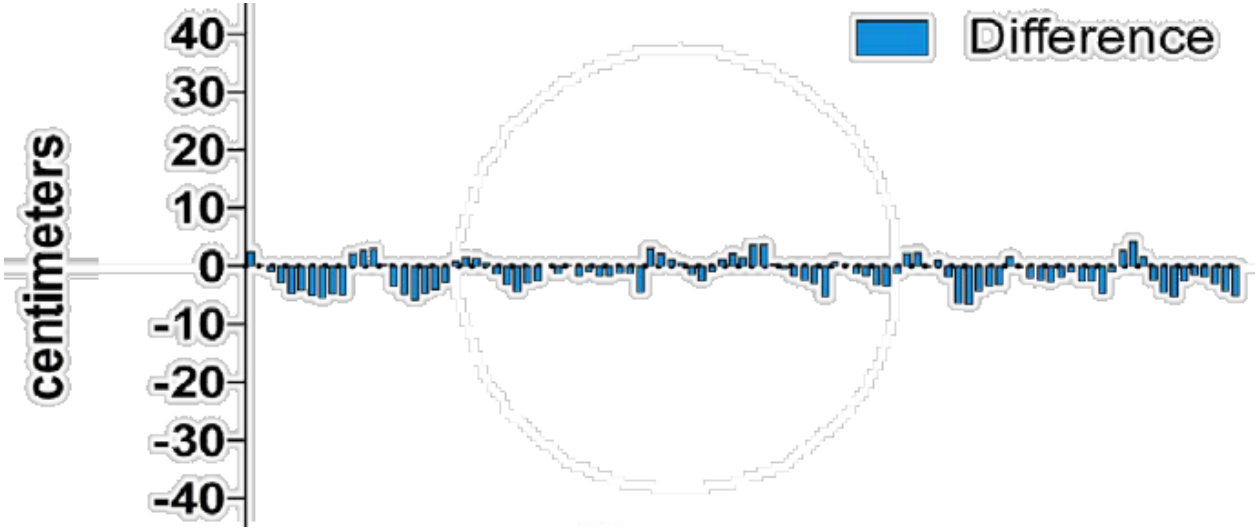
Designed travel	Device	Differences		Percentage of differences	
		X	Y	X	Y
Perimeter of court course	101	5.8	6.2	0,39%	0,41%
	108	5.1	5.1	0,34%	0,34%
Center line of the court	101	7.4	7.2	0,53%	0,51%
	108	11	10.8	0,79%	0,77%
Perimeter of the paint	101	0.3	4.4	0,05%	0,76%
	108	3.3	3.6	0,57%	0,62%
6.75 line	101	1.9	-	0,28%	-
	108	8.6	-	1,27%	-
Center circle	101	5	5.9	3,03%	3,58%
	108	4.1	3.9	2,48%	2,36%
Mean ± SD		5.2 ± 3.1	5.8 ± 2.3	0,97 ± 1	0,94 ± 1,14
LOA (L to U)		2 to 3.1	3.5 to 8.2	-0,03 to 1,98	-0,21 to 2,08

LOA= limits of agreement; L=lower; U=upper

(Unpublished data)

VALIDITY & RELIABILITY

Ultra Wide Band acuracy

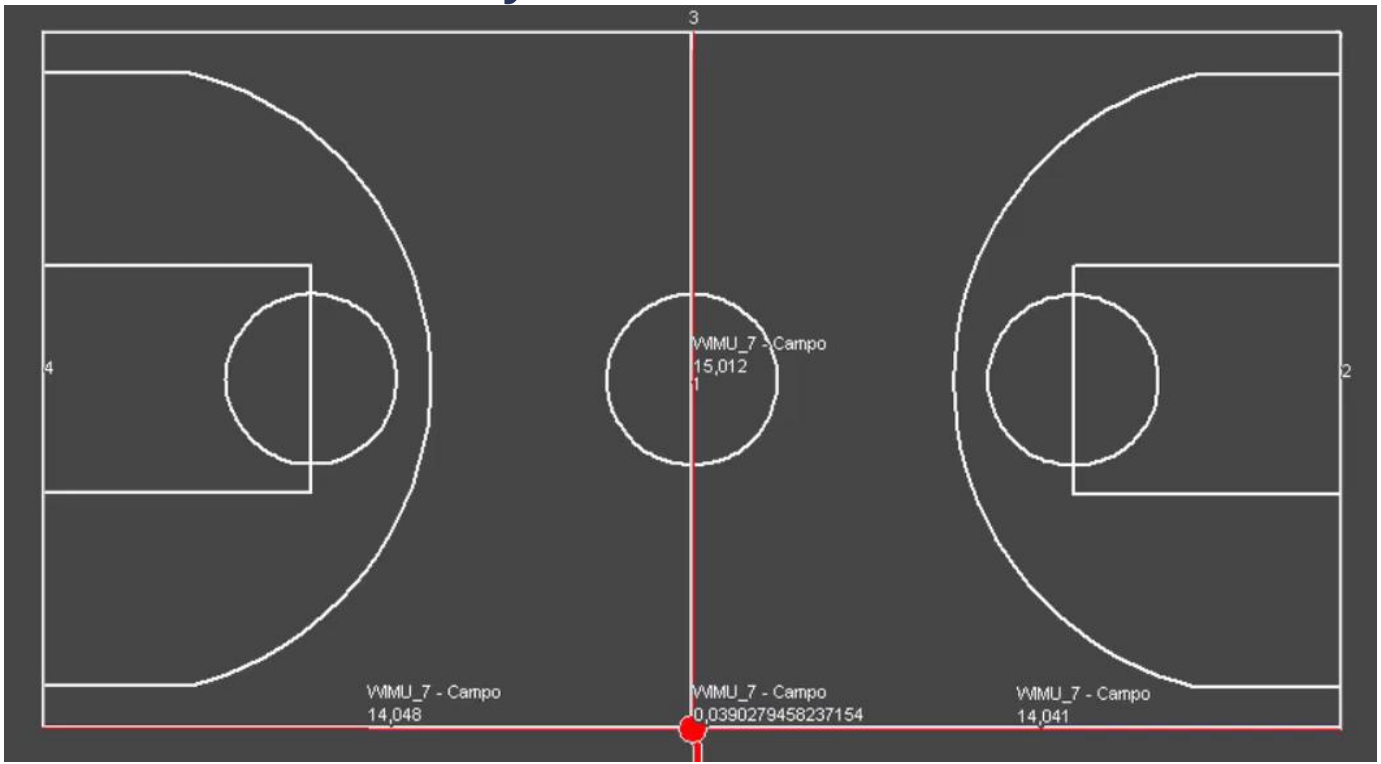


“This index indicates the variation, expressed in centimeters, between the measurement of the device and real measurement.
The precision index is: **-1,441±2,609cm.** ”

(Unpublished data)

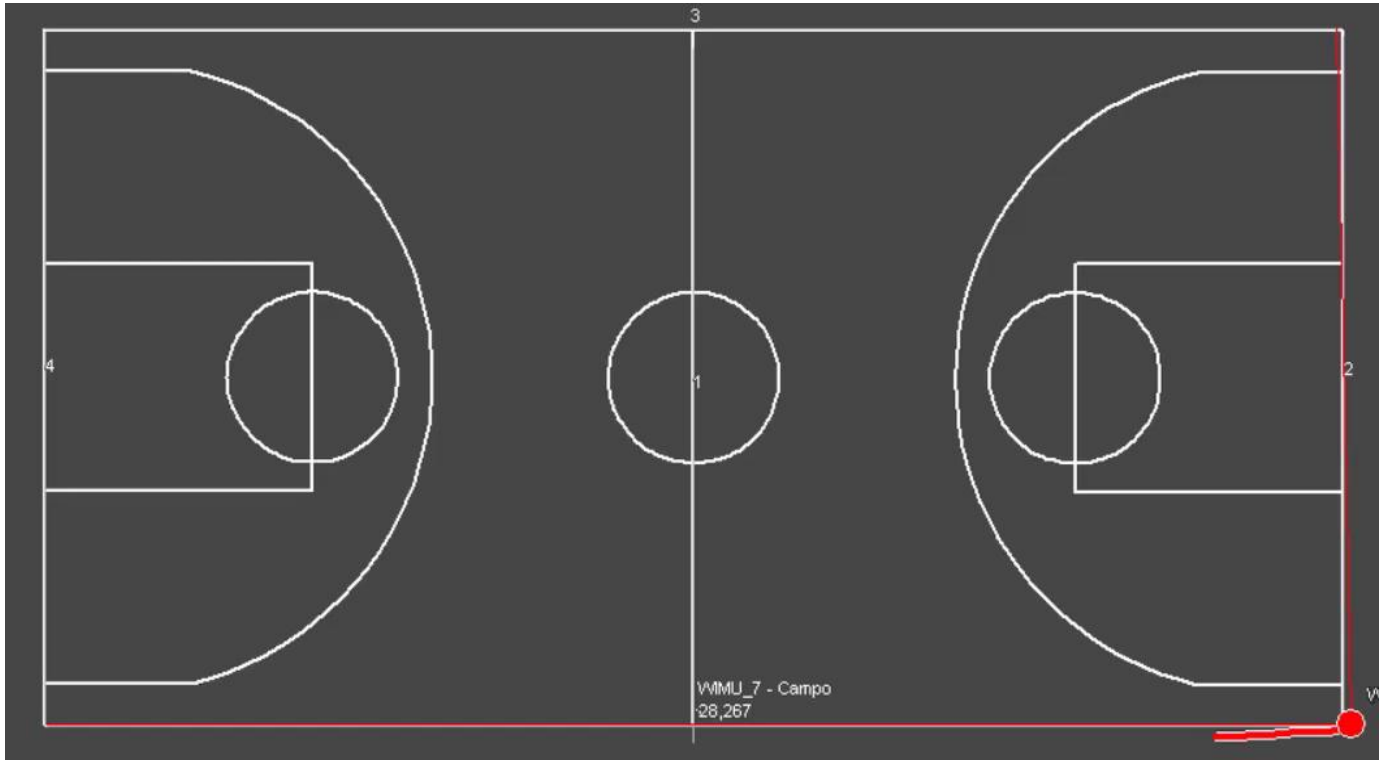
VALIDITY & RELIABILITY

Ultra Wide Band acuracy



VALIDITY & RELIABILITY

Ultra Wide Band acuracy



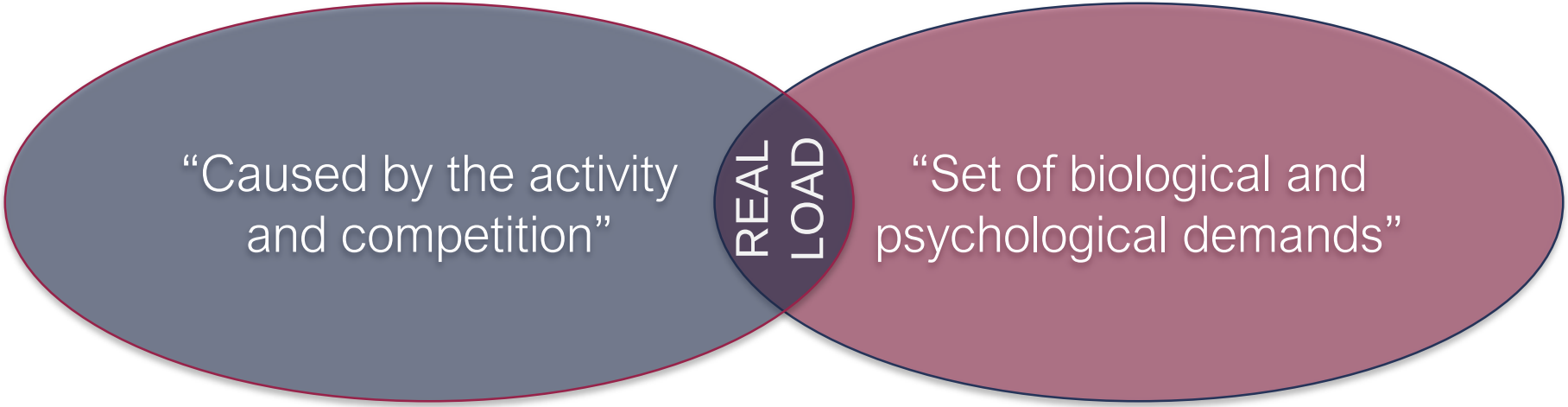
FCB VIEW

For decades, the **monitoring of movements** developed by athletes during training or competition **have interested sport scientists.**

(Carling et al. 2008; Castellano & Casamichana 2014; Lieberman et al. 2002)

FCB VIEW

External load & Internal load

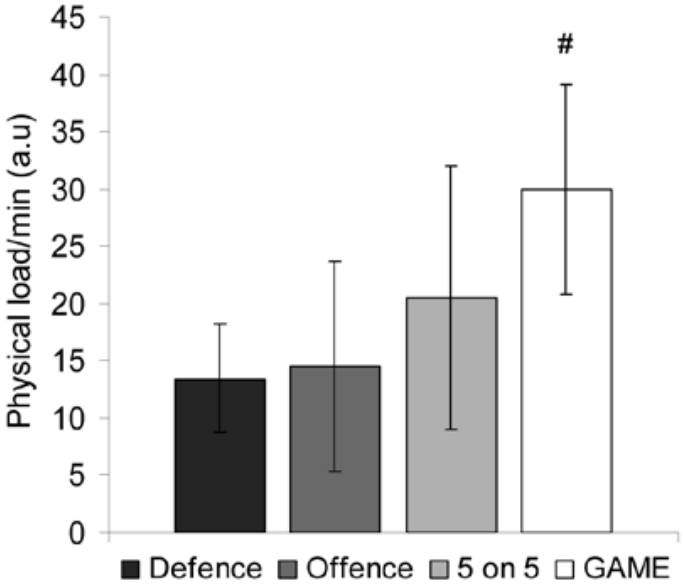


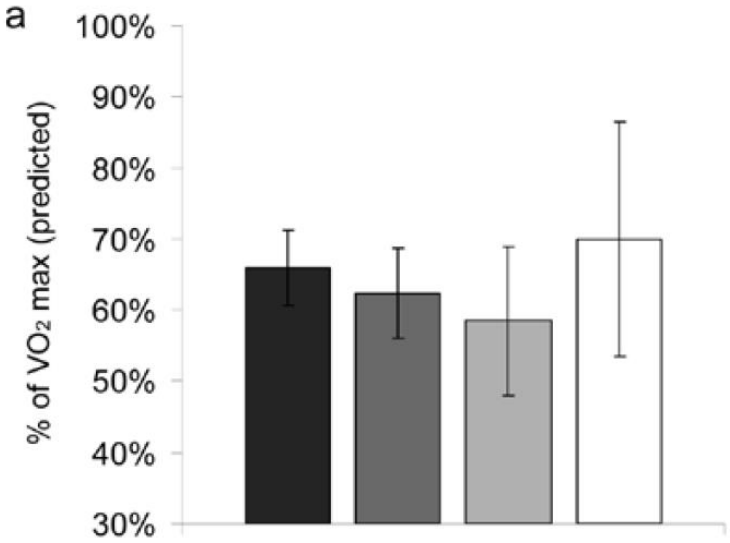
What the player does

What the player feel

(Badillo, 1995)

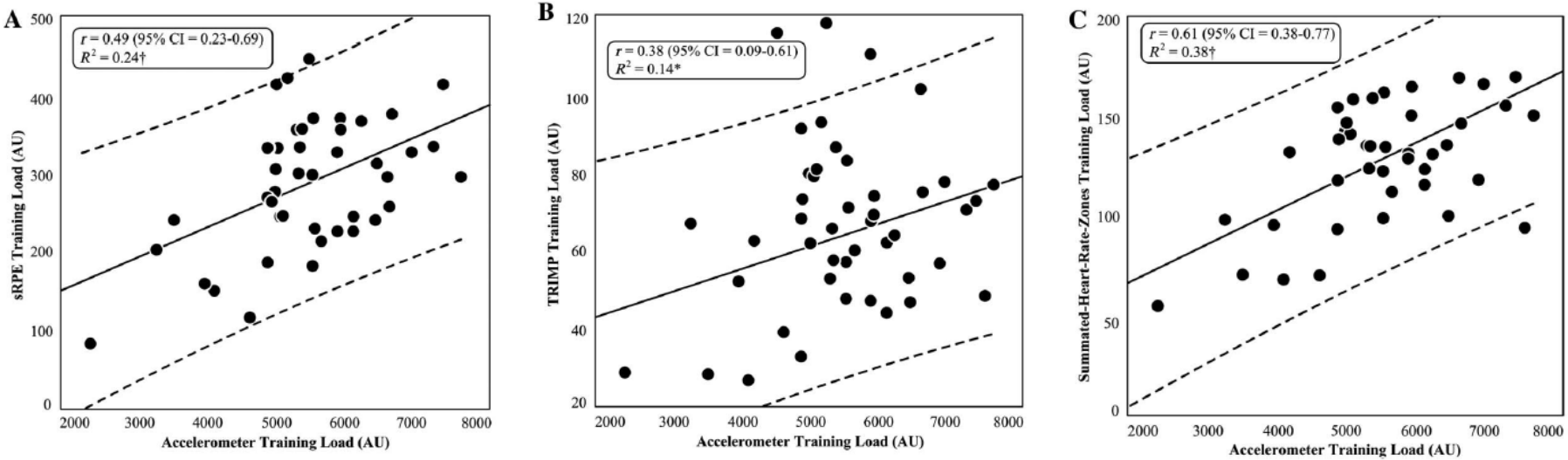
FCB VIEW





(Montgomery, Pyne & Minahan, 2010)

FCB VIEW



"**not assume a linear dose-response** between the **external training load** (detected by accelerometry) and the player's **internal training load** during basketball-specific activities"

(Scanlan, et al., 2014)

FCB VIEW

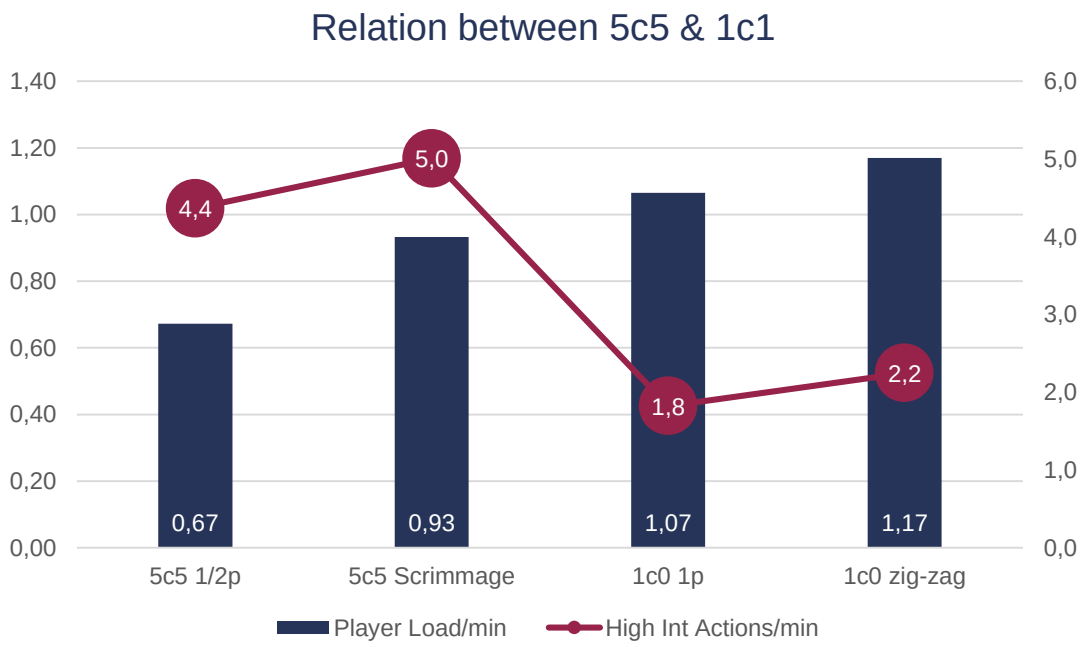
Table 1
Parameter estimates for the linear mixed models ($n = 22{,}080$).

Training output variables	R^2	SBIC	Coefficient ± 90% CL	p Value
Total distance (m)	0.35	4.115	0.02 ± 0.03	0.089
Total high speed distance (m)	0.65	−18.115	0.08 ± 0.03	0.021**
High speed distance (m)	0.69	−39.510	0.09 ± 0.03	0.001**
Maximal velocity (km h^{-1})	0.59	−54.514	0.15 ± 0.09	0.045**
Maximal velocity exposures (n)	0.66	−87.100	0.28 ± 0.08	0.012**
Player load (AU)	0.45	−77.500	0.25 ± 0.04	0.015**
$PlayerLoad_{slow}$ (AU)	0.54	−65.600	0.26 ± 0.09	0.021**
RPE (AU) X	0.59	5.547	−0.04 ± 0.02	0.680
Total distance (m min^{-1}) X	0.21	6.954	0.04 ± 0.02	0.542
Total high speed distance (m min^{-1})	0.56	−19.541	0.21 ± 0.05	0.038**
High speed distance (m min^{-1})	0.69	−115.150	0.26 ± 0.03	0.005**
Maximal velocity exposures (n min^{-1})	0.66	−65.400	0.18 ± 0.08	0.033**
Player load (AU min^{-1})	0.57	−77.551	0.28 ± 0.06	0.048**
$PlayerLoad_{slow}$ (AU min^{-1})	0.38	−101.110	0.26 ± 0.09	0.041**
RPE (AU min^{-1}) X	0.69	1.250	−0.15 ± 0.02	0.870
Total distance:RPE (m min^{-1})	0.28	4.110	−0.13 ± 0.03	0.025**
Total high speed distance:RPE (m min^{-1})	0.48	−10.110	−0.08 ± 0.06	0.015**
Player load:RPE (AU min^{-1}) X	0.41	−15.550	0.15 ± 0.03	0.515
$PlayerLoad_{slow}$:RPE (AU min^{-1})	0.26	−43.220	0.05 ± 0.01	0.001**

** Significant effect during fixed effect testing ($p < 0.05$).

(Malone, et al., 2017)

FCB VIEW



(Unpublished data)

FCB VIEW

MAIN TRACKING VARIABLES (for us)

Volume

- Player load
- Total distance

Intensity

- Distance at high velocity
- High accelerations & decelerations
- High jumpings, landings & impacts
- Number of high intensity actions

Calculated load

- HML Distance
- High speed running
- Dynamic stress load
- Power metabolic average

Density

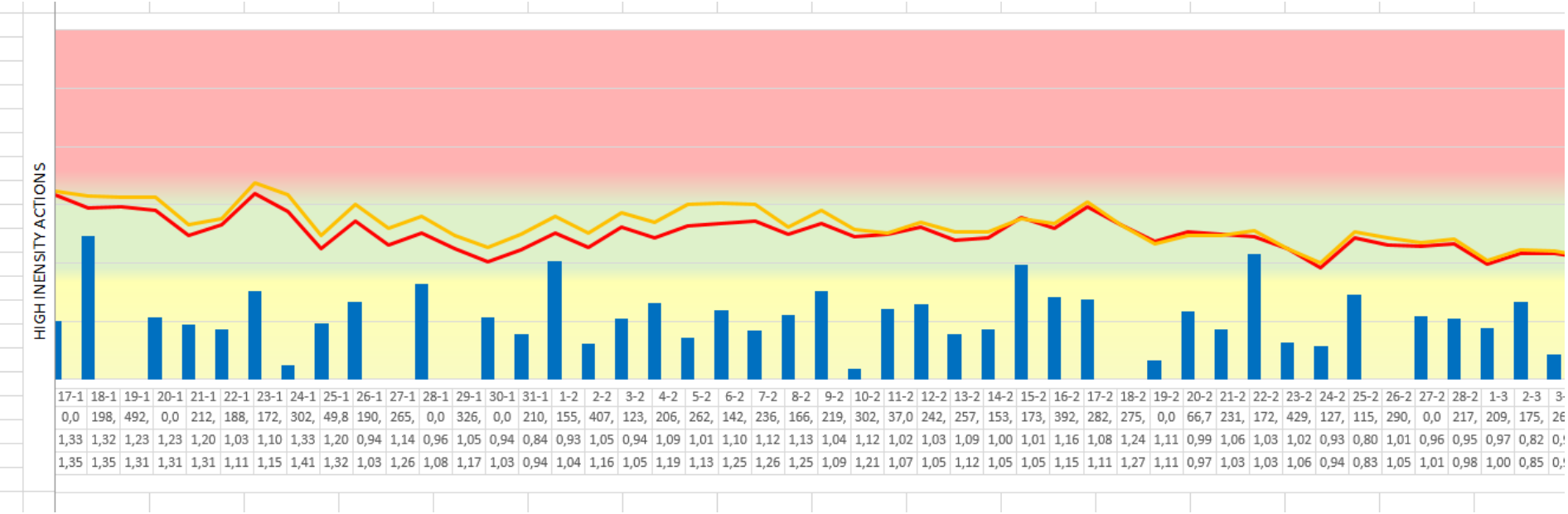
- Ratio Work:Rest time
- All variables realted to minute

Interesting

- Ratio High:Low accelerations
- Ratio Distance at High:Low velocity

FCB VIEW

Examples: Acute:Chronic workload



17-1	18-1	19-1	20-1	21-1	22-1	23-1	24-1	25-1	26-1	27-1	28-1	29-1	30-1	31-1	1-2
0,0	198,	492,	0,0	212,	188,	172,	302,	49,8	190,	265,	0,0	326,	0,0	210,	155,
1,33	1,32	1,23	1,23	1,20	1,03	1,10	1,33	1,20	0,94	1,14	0,96	1,05	0,94	0,84	0,93
1,35	1,35	1,31	1,31	1,31	1,11	1,15	1,41	1,32	1,03	1,26	1,08	1,17	1,03	0,94	1,04

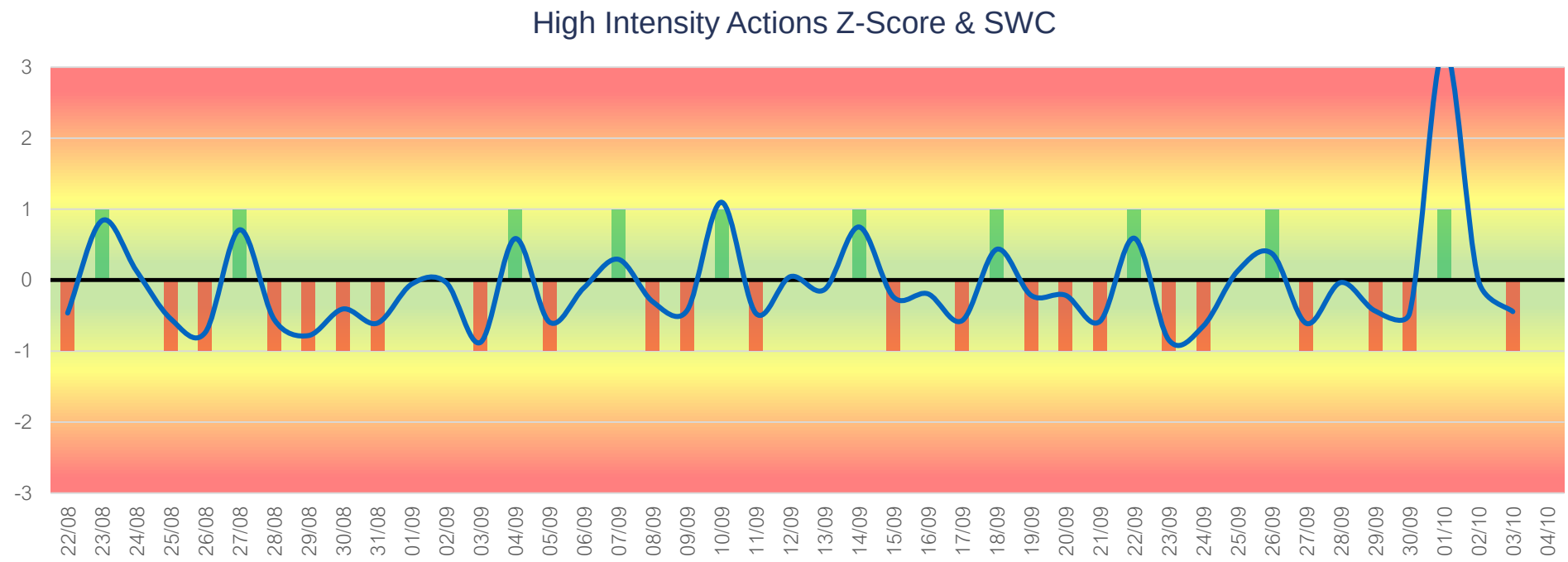
2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2	11-2	12-2	13-2	14-2	15-2	16-2
407,	123,	206,	262,	142,	236,	166,	219,	302,	37,0	242,	257,	153,	173,	392,
1,05	0,94	1,09	1,01	1,10	1,12	1,13	1,04	1,12	1,02	1,03	1,09	1,00	1,01	1,16
1,16	1,05	1,19	1,13	1,25	1,26	1,25	1,09	1,21	1,07	1,05	1,12	1,05	1,05	1,15

17-2	18-2	19-2	20-2	21-2	22-2	23-2	24-2	25-2	26-2	27-2	28-2	1-3	2-3	3-
282,	275,	0,0	66,7	231,	172,	429,	127,	115,	290,	0,0	217,	209,	175,	26
1,08	1,24	1,11	0,99	1,06	1,03	1,02	0,93	0,80	1,01	0,96	0,95	0,97	0,82	0,
1,11	1,27	1,11	0,97	1,03	1,03	1,06	0,94	0,83	1,05	1,01	0,98	1,00	0,85	0,

(adapted from Gabbett et al., 2016)

FCB VIEW

Examples: Z-Score & Smallest Worthwhile Change



FCB VIEW

Acceleration & Speed

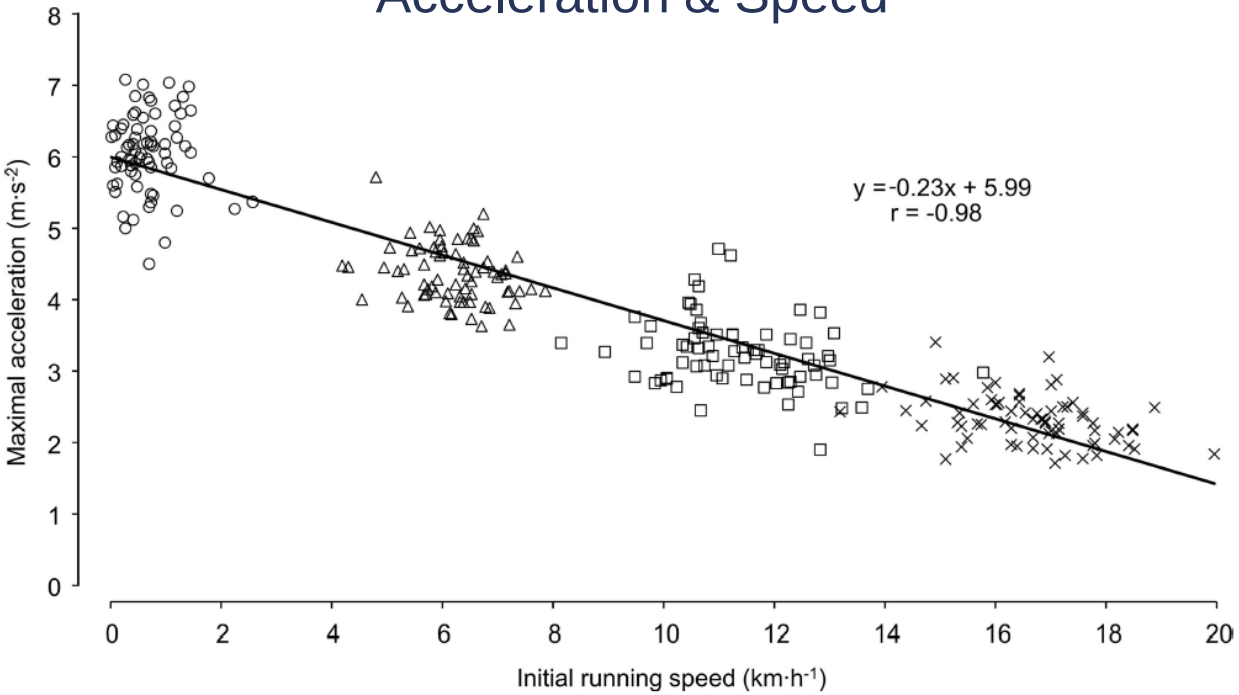


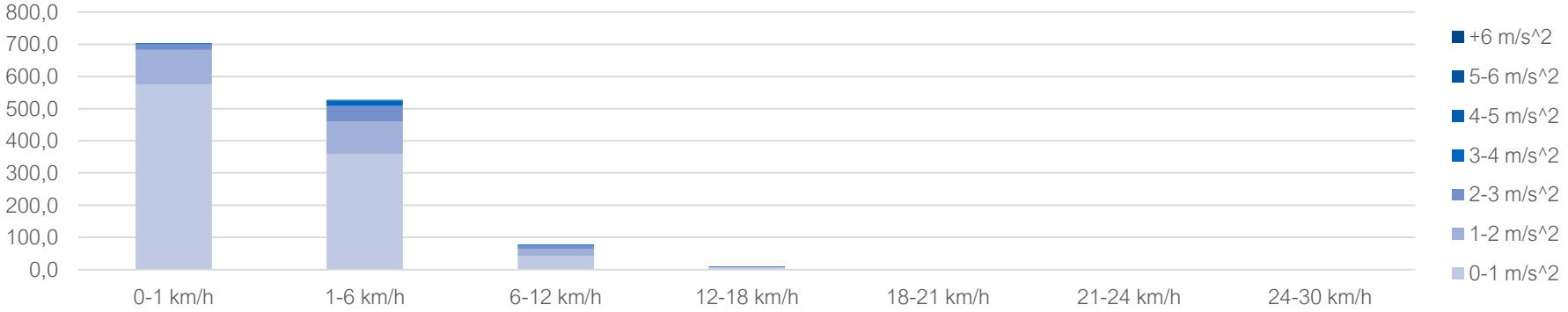
Fig 2. Maximal voluntary accelerations for standing (circles), trotting (triangles), jogging (squares), and running (crosses) of 72 highly trained male soccer players (under 18 league). Simple linear regression line with regression equation and Pearson's correlation coefficient r.

(Sonderegger et al., 2016)

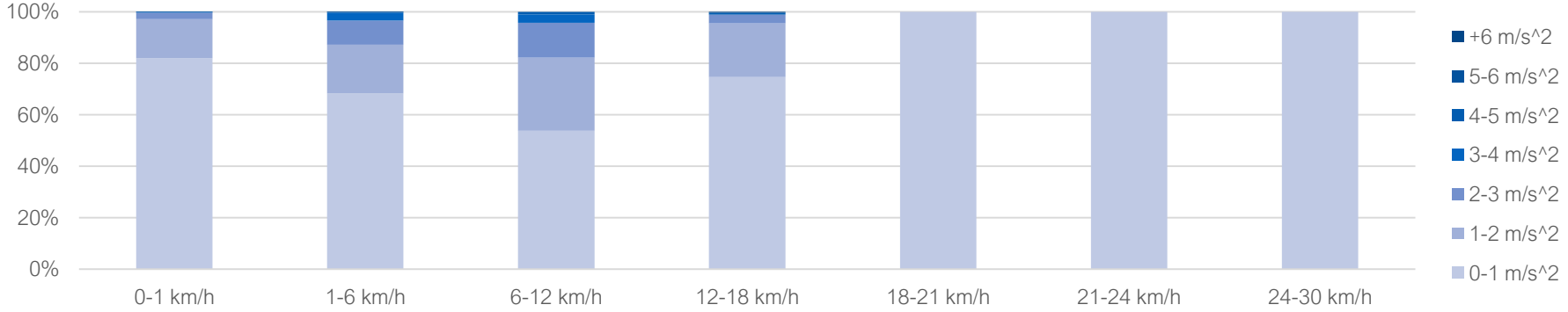
FCB VIEW

Acceleration & Speed

Number of Accelerations / Velocity zone



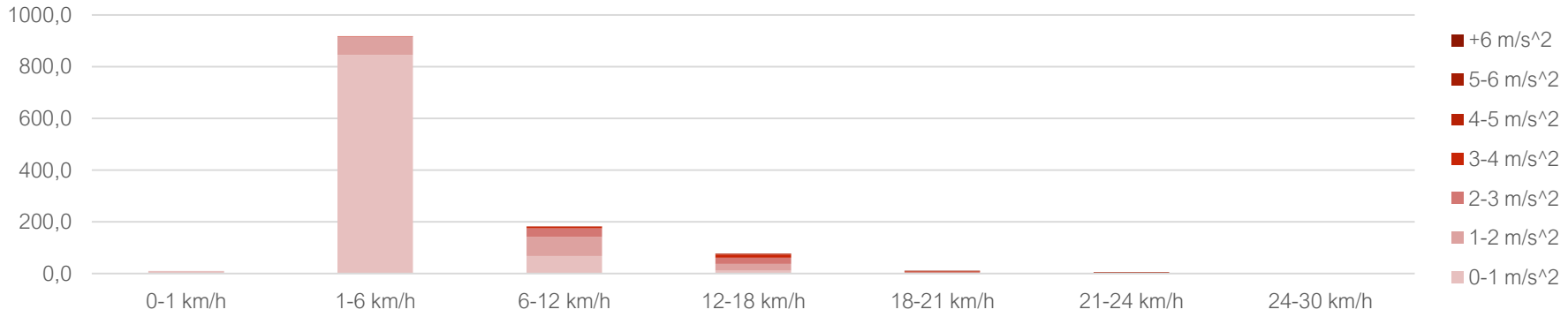
% of Accelerations / Velocity zone



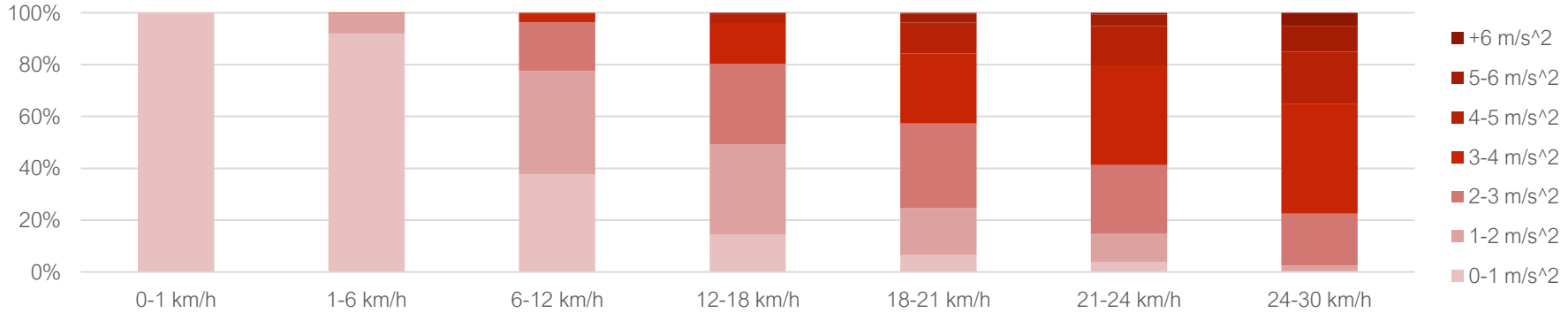
FCB VIEW

Acceleration & Speed

Number of Decelerations / Velocity zones

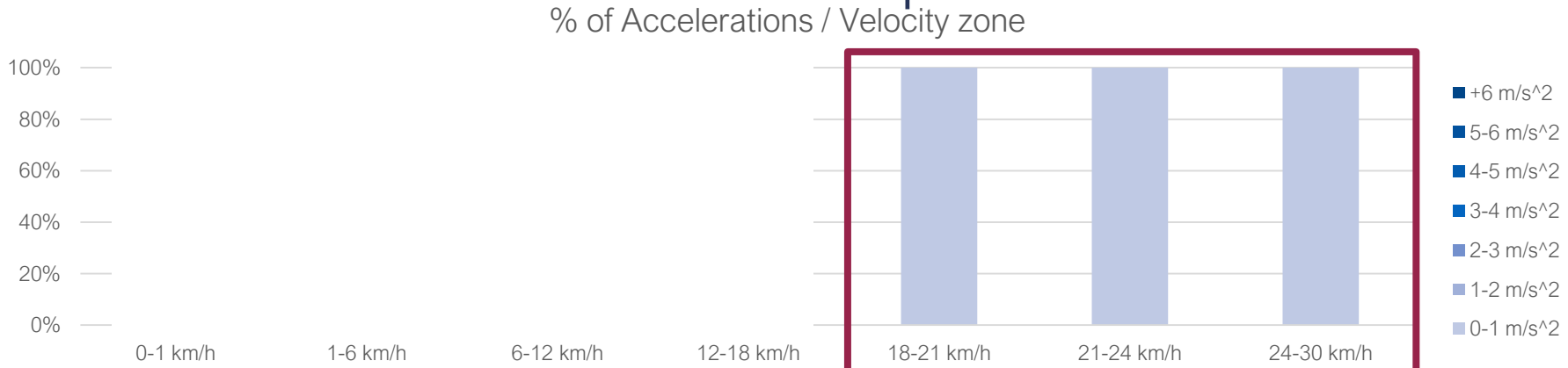


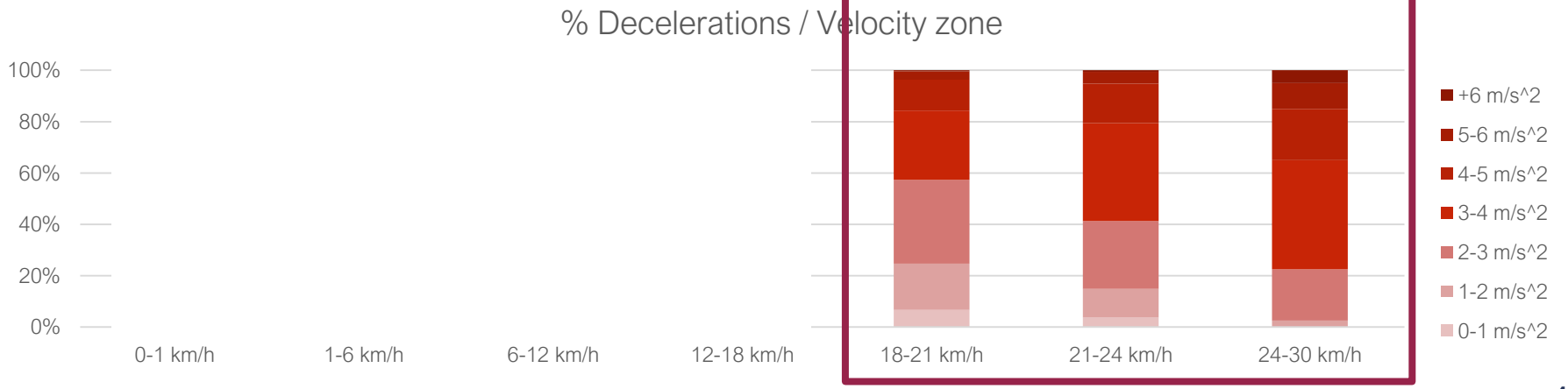
% Decelerations / Velocity zone



FCB VIEW

Acceleration & Speed





FCB VIEW

FCB VIEW

FCB VIEW

TAKE HOME MESSAGE

Be critic with the data you record, be sure that is correct data

FC Barcelona is eager to increase their knowledge in tracking systems

Tracking doesn’t explain all what happens in the field

Thank you!

@XaviReche