

# Physical activity classification in middle-aged recreational marathoners using triaxial accelerometer

Carlos Hernando<sup>1,2</sup>. PhD; Bárbara Hernando<sup>3</sup>. PhD; Carla Hernando<sup>4</sup>. MSc; Eladio J Collado<sup>5</sup>. PhD; Nayara Panizo<sup>5</sup>. PhD; Ignacio Martinez-Navarro<sup>6,7</sup>. PhD.

<sup>1</sup> Sport Service. Jaume I University; <sup>2</sup> Department of Education. Jaume I University; <sup>3</sup> Department of Medicine. Jaume I University; <sup>4</sup> Department of Mathematics. Carlos III University of Madrid; <sup>5</sup> Faculty of Health Sciences. Jaume I University; <sup>6</sup> Department of Physical Education and Sport. University of Valencia; <sup>7</sup> Sports Health Unit. Vithas-Nisa 9 de Octubre Hospital

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# The use of accelerometers in physical activity evaluation



## Strengths

- Concurrent measure of movement
- Provides detailed intensity, frequency and duration data
- Can store data for weeks at a time
- Low burden and easy to wear
- Relatively inexpensive
- Does not depend on other connections or devices
- Does not disturb the daily live



## Weaknesses

- Can not account for all activities, such as stair use, lifting a load
- Body location decision is vital (i.e. upper-body activities neglected with hip or lower-back wear)
- Calibration needs to be performed according to study characteristics (specific cut points)
- Data reduction, transformation and processing take time

# Validation of the GENEActiv Accelerometer

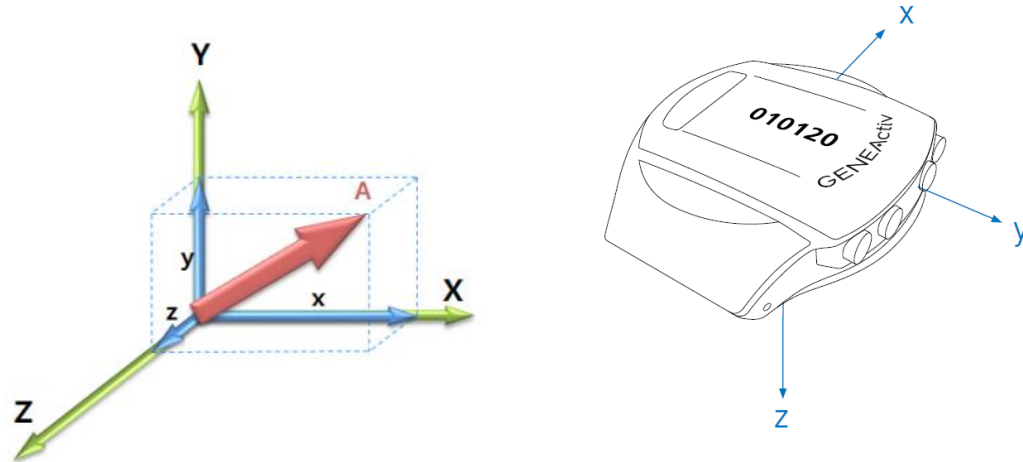
DALE W. ESLIGER<sup>1,2</sup>, ANN V. ROWLANDS<sup>1</sup>, TINA L. HURST<sup>3</sup>, MICHAEL CATT<sup>3,4</sup>, PETER MURRAY<sup>3</sup>, and ROGER G. ESTON<sup>1</sup>

<sup>1</sup>School of Sport and Health Sciences, St Luke's Campus, University of Exeter, Exeter, England, UNITED KINGDOM;

<sup>2</sup>College of Kinesiology, University of Saskatchewan, Saskatoon, Saskatchewan, CANADA; <sup>3</sup>Unilever Discover, Colworth, West Sussex, England, UNITED KINGDOM; and <sup>4</sup>Institute for Ageing and Health, Newcastle University, Newcastle Upon Tyne, UNITED KINGDOM

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$$SVM_{gs} = \sum |\sqrt{x^2 + y^2 + z^2} - g|$$

TABLE 4. Sensitivity, specificity, area under the ROC curve, and GENEActiv SVM<sub>gs</sub> (g·min) cut points that maximized sensitivity and specificity at three wear positions.

Intensity <sup>a</sup>	Sensitivity	Specificity	Area Under ROC Curve (95% CI)	GENEActiv Cut Points SVM <sub>gs</sub> (g·min)
<b>Left wrist</b>				
Sedentary	97	95	0.98 (0.98–0.99)	<217
Light	NA	NA	NA	217–644
Moderate	95	72	0.91 (0.88–0.93)	645–1810
Vigorous	78	98	0.91 (0.86–0.95)	>1810
<b>Right wrist</b>				
Sedentary	99	96	0.98 (0.97–0.99)	<386
Light	NA	NA	NA	386–439
Moderate	100	56	0.84 (0.81–0.87)	440–2098
Vigorous	78	97	0.89 (0.84–0.94)	>2098
<b>Waist</b>				
Sedentary	99	96	0.97 (0.96–0.98)	<77
Light	NA	NA	NA	77–219
Moderate	96	80	0.93 (0.91–0.95)	220–2056
Vigorous	73	99	0.92 (0.88–0.96)	>2056

<sup>a</sup> Sedentary (<1.5 METs), light (1.5–3.99 METs), moderate (4.00–6.99 METs), and vigorous (7+ METs).

NA, not applicable as the sedentary and moderate cut points provide the boundaries for the light-intensity category.

# Objective

- To establish GENEa cut-points for discriminating between six relative-intensity activity levels in middle-aged recreational marathoners

# Material and Methods

- Runners characteristics for inclusion:

- Age: from 30 to 45 years old
- Health: Free from cardiac or renal disease and from consuming drugs.
- Marathon PB:
  - Males: within 3 to 4 hours
  - Females: within 3h30min to 4h30min
- Body Mass Index: from 16 to 24.99 kg·m<sup>2</sup>

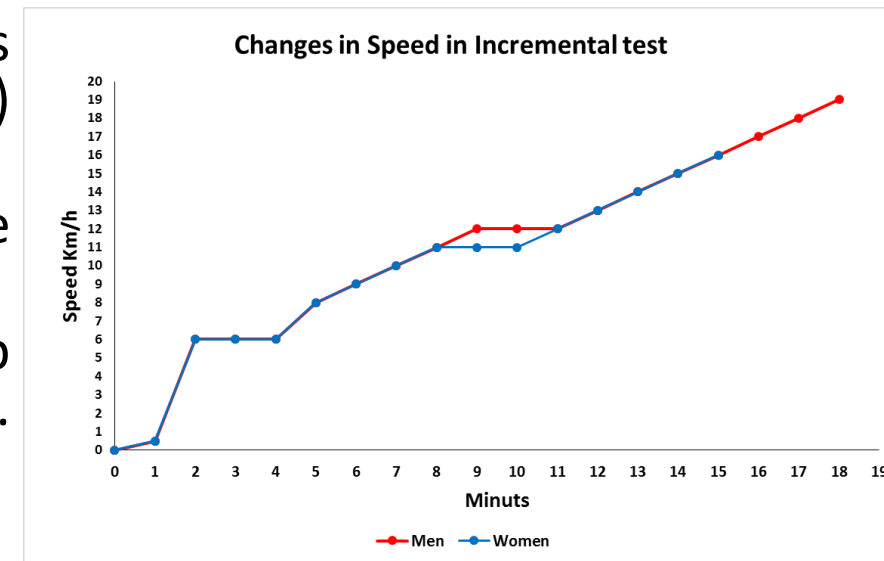


- Ethics Statements:

- All individuals included in the current study were fully informed and gave their written consent to participate.
- The research was conducted according to the Declaration of Helsinki. and it was approved by the Research Ethics Committee of the Jaume I University of Castellon.

# Material and Methods

- Each participant completed a **standardized questionnaire** to collect demographic information, as well as medical information, training plan and competition history.
- Each participant complete a **cardiopulmonary exercise test**
  - The test was done on a treadmill (pulsar<sup>®</sup> 3p. h/p/cosmos sports & medical gmbh. Nussdorf-Traunstein. Germany) until exhaustion
  - Breath-by-breath gas exchange was measured by the Jaeger MasterScreen<sup>®</sup> CPX gas analyzer
  - The test was an adaptation of the incremental ramp exercise protocol (Myers J. Bellin D. 2000; Boone J. Bourgois J. 2012)



# Material and Methods



*GENEActiv* accelerometer (Activinsights Ltd., Kimbolton, Cambridgeshire, United Kingdom).

- The accelerometer was worn during all time of the cardiopulmonary exercise test
- Non dominant wrist as a watch
- Frequency: 85.70 Hz
- Epoch: average each minute ( $\text{SVMgs}\cdot\text{min}^{-1}$ )

# Material and Methods

- Cut points of Physical Activity:
  - Relative intensity categories of physical activity according to individualized  $\dot{V}O_{2\max}$  (modification from Strath *et al.* 2013):
    - Sedentary:  $\dot{V}O_2 < 10\% \dot{V}O_{2\max}$
    - Light:  $10\% \leq \dot{V}O_2 \leq 25\% \dot{V}O_{2\max}$
    - Moderate:  $25\% \leq \dot{V}O_2 \leq 45\% \dot{V}O_{2\max}$
    - Vigorous:  $45\% \leq \dot{V}O_2 \leq 65\% \dot{V}O_{2\max}$
    - Very Vigorous:  $65\% \leq \dot{V}O_2 \leq 85\% \dot{V}O_{2\max}$
    - Extremely Vigorous:  $\dot{V}O_2 \geq 85\% \dot{V}O_{2\max}$
- Statistics:
  - Receiver Operation Curve (Curve ROC)
    - Youden Index
    - Area Under Curve (AUC). Sensibility & Specificity





# Results

	Variable	All participants (N = 98)	Males (N = 83)	Females (N = 15)
Physiological characteristics *	Age	38.72 ± 3.63	38.76 ± 3.65	38.50 ± 3.63
	BMI	22.87 ± 1.71	23.18 ± 1.48	21.32 ± 2.01
	% Fat	14.74 ± 3.25	13.81 ± 3.67	19.54 ± 4.16
	<b>VO<sub>2max</sub> (ml·kg<sup>-1</sup>·min<sup>-1</sup>)</b>	<b>54.53 ± 5.63</b>	<b>55.74 ± 5.14</b>	<b>48.27 ± 3.60</b>
Training indicators *	Sessions per week	4.81 ± 0.86	4.90 ± 0.85	4.33 ± 0.81
	Kilometers per week	63.16 ± 13.42	64.45 ± 13.21	55.66 ± 12.79
	Hours per week	7.30 ± 2.67	7.46 ± 2.69	6.21 ± 2.27
History as marathoner *	Marathons finished	3.28 ± 3.00	3.56 ± 3.09	1.92 ± 2.08
	Marathon per year	1.09 ± 0.61	1.21 ± 0.61	0.93 ± 0.59
	Marathon PB	3:34:47 ± 20:50	3:31:03 ± 19:10	3:54:30 ± 18:27
Work intensity #	High intensity	7.07%	8.43%	0%
	Medium intensity	31.31%	31.32%	31.25%
	Low intensity	61.61%	60.24%	68.75%
Levels of study #	School graduate	5.10%	4.87%	6.25%
	High school graduate	6.12%	6.09%	6.25%
	Professional certificate	16.32%	18.29%	6.25%
	Undergraduate degree	72.4%	70.73%	81.25%

Abbreviations: N, number of samples; BMI, body mass index; SD, standard deviation

\* Values are presented as mean ± SD

# Values are presented as percentage of all individuals, males and females

# Results

Relative-intensity categories of physical activity according to individualized  $\dot{V}O_{2max}$  measured in 98 adult marathon runners

Relative-intensity levels of physical activity #	All samples (N = 98)		Males (N = 83)		Females (N = 15)	
	$\dot{V}O_2$ (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )	METs *	$\dot{V}O_2$ (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )	METs *	$\dot{V}O_2$ (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )	METs *
Sedentary X < 10%	$\dot{V}O_2 < 5.45$	METs < 1.56	$\dot{V}O_2 < 5.57$	METs < 1.59	$\dot{V}O_2 < 4.82$	METs < 1.38
Light 10% ≤ X < 25%	$5.45 \leq \dot{V}O_2 < 13.63$	$1.56 \leq \text{METs} < 3.90$	$5.57 \leq \dot{V}O_2 < 13.94$	$1.59 \leq \text{METs} < 3.97$	$4.82 \leq \dot{V}O_2 < 12.07$	$1.38 \leq \text{METs} < 3.45$
Moderate 25% ≤ X < 45%	$13.63 \leq \dot{V}O_2 < 24.54$	$3.9 \leq \text{METs} < 7.01$	$13.94 \leq \dot{V}O_2 < 25.08$	$3.97 \leq \text{METs} < 7.15$	$12.07 \leq \dot{V}O_2 < 21.72$	$3.45 \leq \text{METs} < 6.21$
Vigorous 45% ≤ X < 65%	$24.54 \leq \dot{V}O_2 < 35.44$	$7.01 \leq \text{METs} < 10.13$	$25.08 \leq \dot{V}O_2 < 36.23$	$7.15 \leq \text{METs} < 10.33$	$21.72 \leq \dot{V}O_2 < 31.38$	$6.21 \leq \text{METs} < 8.97$
Very Vigorous 65% ≤ X < 85%	$35.44 \leq \dot{V}O_2 < 46.35$	$10.13 \leq \text{METs} < 13.24$	$36.23 \leq \dot{V}O_2 < 47.38$	$10.33 \leq \text{METs} < 13.50$	$31.38 \leq \dot{V}O_2 < 41.03$	$8.97 \leq \text{METs} < 11.72$
Extremely Vigorous X ≥ 85%	$\dot{V}O_2 \geq 46.35$	METs ≥ 13.24	$\dot{V}O_2 \geq 47.38$	METs ≥ 13.50	$\dot{V}O_2 \geq 41.03$	METs ≥ 11.72

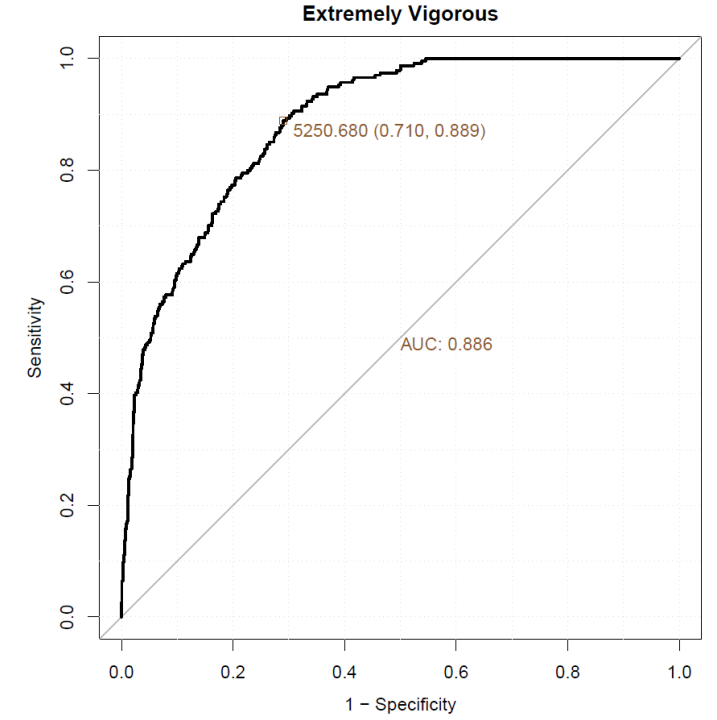
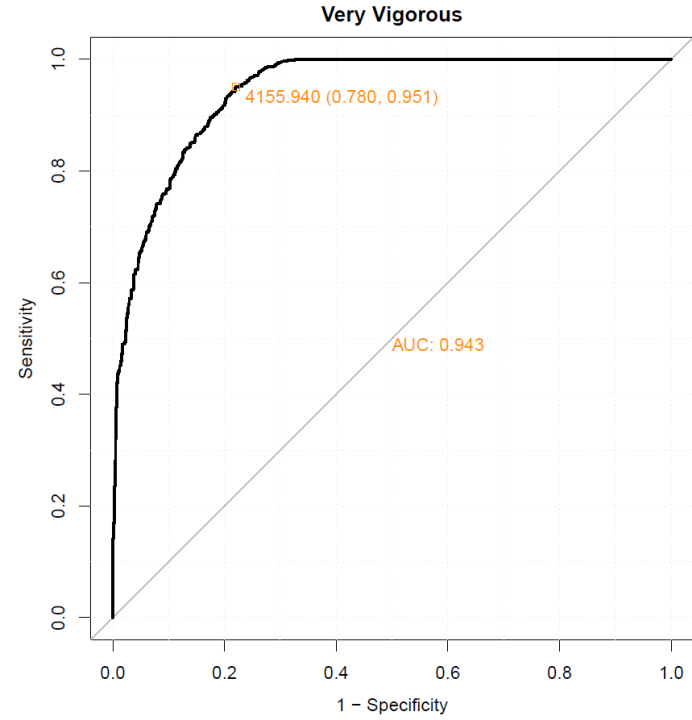
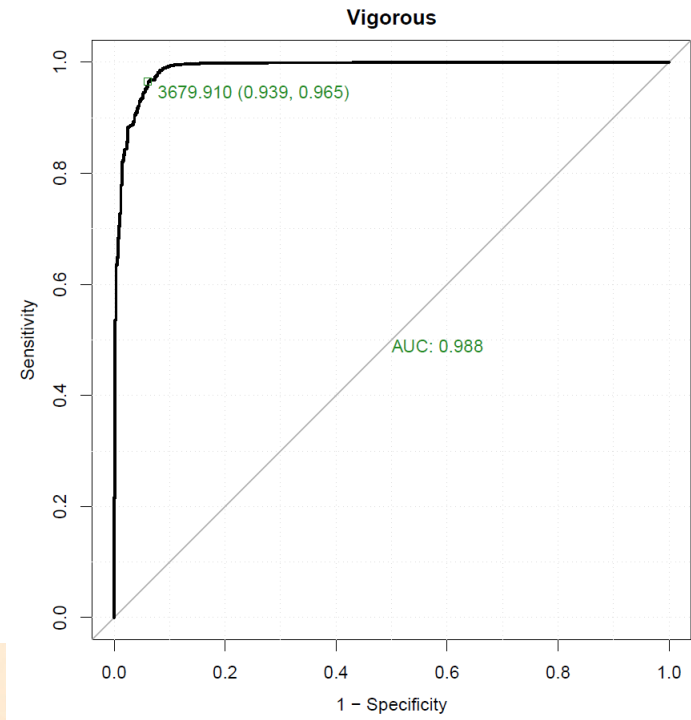
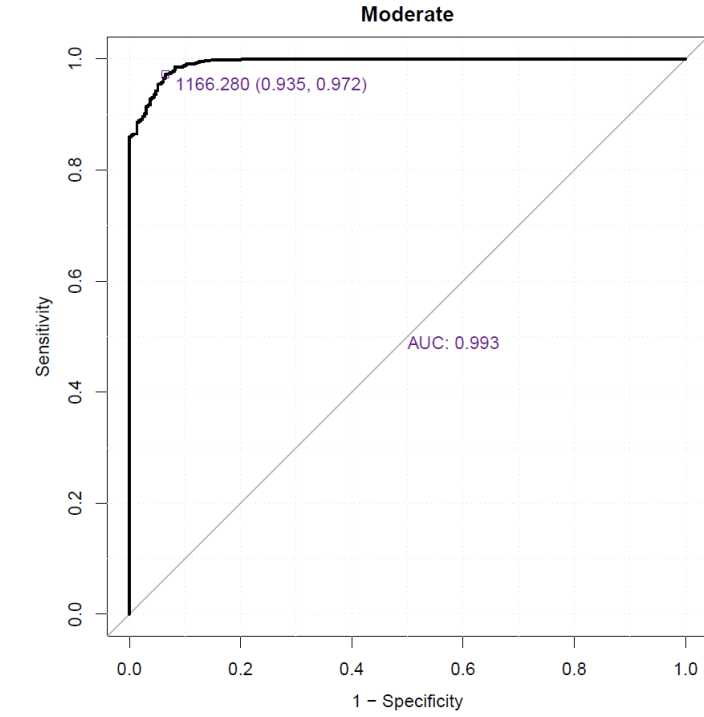
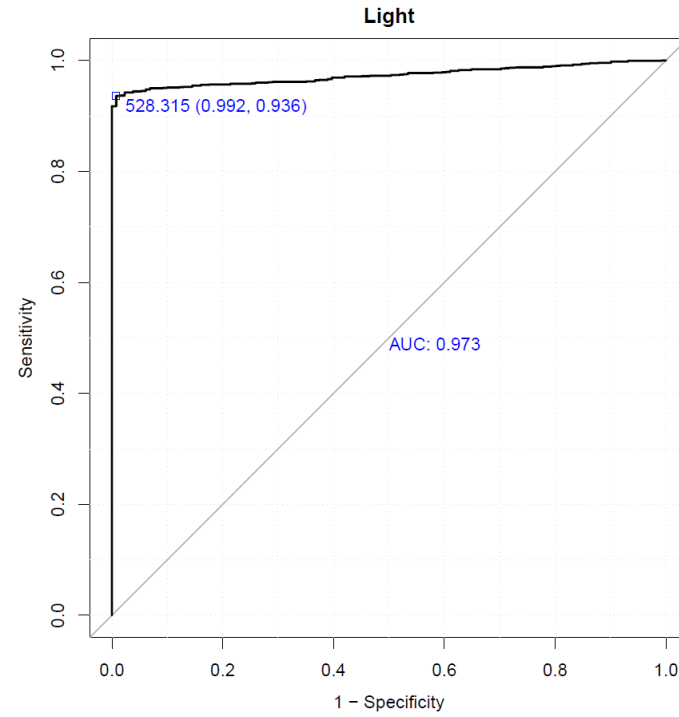
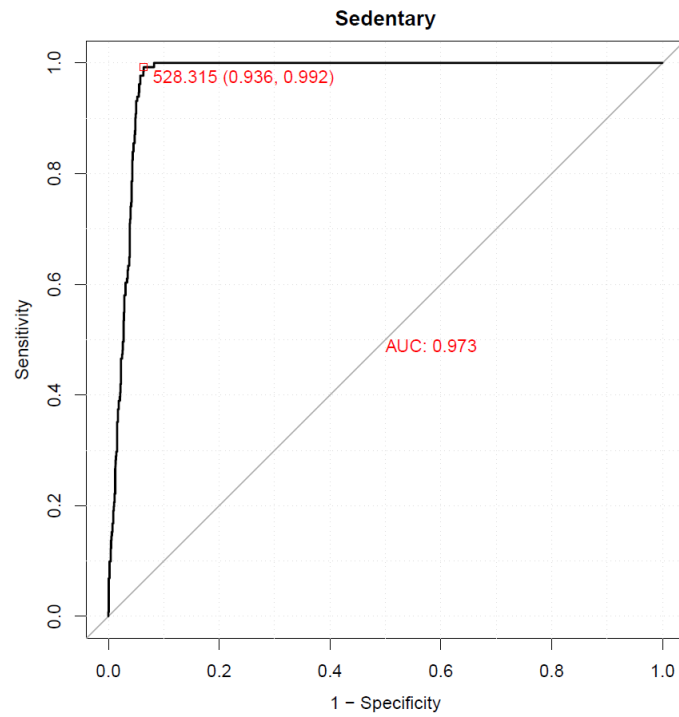
Abbreviations: N, number of individuals;  $\dot{V}O_{2max}$ , maximum oxygen consumption; MET, metabolic equivalent task

Each minute of the cardiopulmonary test was classified into one of the six intensity categories of physical activity relative to an individual's level of cardiorespiratory ( $\dot{V}O_{2max}$ ).

\* 1 MET = 3.5 ml·kg<sup>-1</sup>·min<sup>-1</sup>

# X denotes the percentage of a person's aerobic capacity ( $\dot{V}O_{2max}$ ) used to classify each one of the six relative-intensity categories

# Results



# Results



## Performance analysis of wrist-worn GENE A cut-points for each intensity level in adult marathon runners

Intensity level of physical activity	Sensitivity (%)	Specificity (%)	Area under the ROC curve (95% CI)	GENEA cut-points in SVM <sub>gs</sub> (g·min) *
<b>All samples (N = 98)</b>				
Sedentary	99.2	93.6	0.973 (0.966-0.980)	SVM <sub>gs</sub> < 528.31
Light	93.6	99.2	0.973 (0.966-0.980)	528.31 ≤ SVM <sub>gs</sub> < 1166.28
Moderate	97.2	93.5	0.993 (0.990-0.996)	1166.28 ≤ SVM <sub>gs</sub> < 3679.91
Vigorous	96.5	93.9	0.988 (0.984-0.993)	3679.91 ≤ SVM <sub>gs</sub> < 4155.94
Very Vigorous	95.1	78.0	0.943 (0.933-0.954)	4155.94 ≤ SVM <sub>gs</sub> < 5250.68
Extremely Vigorous	88.9	71.0	0.886 (0.867-0.905)	SVM <sub>gs</sub> ≥ 5250.68
<b>Males (N = 83)</b>				
Sedentary	99.1	94.0	0.973 (0.966-0.981)	SVM <sub>gs</sub> < 528.31
Light	94.0	99.1	0.973 (0.966-0.981)	528.31 ≤ SVM <sub>gs</sub> < 1166.28
Moderate	97.0	93.2	0.992 (0.989-0.996)	1166.28 ≤ SVM <sub>gs</sub> < 3679.91
Vigorous	97.6	93.8	0.99 (0.985-0.995)	3679.91 ≤ SVM <sub>gs</sub> < 4364.64
Very Vigorous	91.7	80.9	0.94 (0.929-0.952)	4364.64 ≤ SVM <sub>gs</sub> < 5264.37
Extremely Vigorous	89.9	70.3	0.881 (0.859-0.903)	SVM <sub>gs</sub> ≥ 5264.37
<b>Females (N = 15)</b>				
Sedentary	100	93.0	0.968 (0.946-0.990)	SVM <sub>gs</sub> < 326.08
Light	93.0	100	0.968 (0.946-0.990)	326.08 ≤ SVM <sub>gs</sub> < 1264.59
Moderate	98.3	97.8	0.995 (0.989-1.000)	1264.59 ≤ SVM <sub>gs</sub> < 2717.5
Vigorous	97.8	93.8	0.988 (0.977-0.999)	2717.5 ≤ SVM <sub>gs</sub> < 3355.56
Very Vigorous	98.3	86.5	0.97 (0.951-0.989)	3355.56 ≤ SVM <sub>gs</sub> < 5796.21
Extremely Vigorous	86.1	82.5	0.924 (0.883-0.965)	SVM <sub>gs</sub> ≥ 5796.21

Abbreviations: N. number of samples; ROC. receiver operation curve; CI. coefficient interval; SVM<sub>gs</sub>. signal magnitude vector gravity-subtracted

\* Optimal cut-points maximising Youden Index

# Conclusions

- The wrist-worn GENE A accelerometer presents a high capacity of classifying the intensity of physical activity in middle-aged recreational marathoners when examining all samples together, as well as when sample set was separated by sex
- This study suggests that the triaxial GENE A accelerometers (worn on the non-dominant wrist) can be used to predict energy expenditure for running activities

# Financial support





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