A smartphone application to evaluate energy expenditure and duration of moderate-intensity activities

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Introduction

Evaluating energy expenditure in free-living conditions is currently possible using expensive and constraining methods, such as doubly-labelled water, calorimetric room or research sensors.

Aim

The aim of our study was to find functions for estimating energy expenditure in free-living conditions. This method was based on accelerometry data acquired from a smartphone worn in a trouser pocket. The developed functions have been compared to the estimations provided by two research devices named Armband and Actiheart.

Two functions have been developed: 1) f(AEDES), based on activity recognition; 2) f(NRJSI), based on the signal energy.

Methods

18 normal weighted volunteers wore 3 monitors (Android smartphone, Actiheart and Armband)

	Controlled conditions (3h30)	Free-living conditions (1 day)
Reference	Compendium of physical activities	Armband, Actiheart & Compendium
Size	6 men, 6 women	3 men, 3 women
Age	34 ± 10y	34 ± 9y
Activities	sitting, standing, running, climbing/descending stairs, walking slowly/normally/ quickly, transportation	Free

Function : $f^{\alpha,K}_{x,y,z,t,d,P} = g_{x,y,z,t,d,P} \times \lambda$ with α and K coefficients to determine

(x, y, z, t)	Accelerometry data and time
d	Duration (in seconds)
P	Volunteer weight (in kg)
$g_{x,y,z,t,d,P}$	EE estimator (can be $g(AEDES)$ or $g(NRJSI)$)
λ	Corrective factor

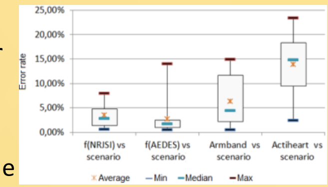
Error of EE estimation (%) : $\varepsilon = \left| \frac{EE\ estimation - EE\ reference}{EE\ reference} \right|$

Paired t-test to compare the error levels of monitors

Results

Differences between EE estimated by the functions, the sensors and the Compendium in controlled conditions

Results showed that f(AEDES) and f(NRJSI) have similar error rates in controlled conditions (2,7 ± 3,5% vs. 3,5 ± 2,4%).



A paired t-test showed that the differences between AEDES and Actiheart, and between NRJSI and Actiheart are both significantly different. Conversely, no difference in error was observed between the functions and Armband.

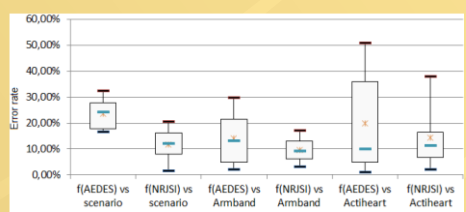
Differences between EE estimated by the functions, the sensors and the Compendium in free-living conditions

Each function has been compared to the Compendium of physical activities, the Armband and the Actiheart. However, according to (Rousset S. & al., 2011), the Armband is more precise for low and moderate intensity activities.

The results showed that f(NRJSI) was a little more accurate than f(AEDES), whatever the chosen reference.

Error of $f^{\alpha=0.747, K=1.132}_{x,y,z,t,d,P}(AEDES)$: 14.0 ± 10.4%

Error of $f^{\alpha=0.486, K=0.000713}_{x,y,z,t,d,P}(NRJSI)$: 9.6 ± 4.8%.



Activity intensity recognition in free-living conditions

Three categories have been created: 1) motionless activities (less than 2 METs); 2) low to moderate intensity activities (from 2 to 6 METs); 3) vigorous activities (6 METs or more).

It turned out the 3 monitors have recognized approximately the same rates of motionless, low/moderate and vigorous activities on average.

Conclusion

Both f(AEDES) and f(NRJSI) have low error rates compared to Armband in controlled and free-living conditions. However, the coefficients of the function f have been computed using all the volunteer's data available (18 subjects). The next step will consist in testing the functions over 24 new volunteers in order to validate the results.
Moreover, the recognition and classification of activity intensities are similar for f(AEDES), Armband and Actiheart.