Monitoring fitness levels and detecting implications for health on a large scale of the general population

Hala Nassif, Adrien Sedeaud, Elisa Abidh, Julien Schipman, Muriel Tafflet, Thibault Deschamps, Hervé Maillet, Hervé Ovigneur, François-Denis Desgorces, Jean-François Toussaint

Monitoring fitness levels and detecting implications for health on a large scale of the general population

Hala Nassif MS * [a b], Adrien Sedeaud MS [a b], Elisa Abidh [e], Julien Schipman MS [a], Muriel Tafflet MS [a c], Thibault Deschamps [f], Hervé Maillet [f], Hervé Ovigneur [f], François Desgorces PhD [a b], Jean-François Toussaint MD PhD [a b d]

[a] IRMES, INSEP, 11 avenue du Tremblay, 75012 Paris, France

[b] Université Paris-Descartes, Sorbonne Paris Cité, 12 rue de l'école de médecine, 75006 Paris, France

[c] INSERM, U970, Paris Cardiovascular Research Center - PARC C, 56 rue Leblanc 75015 Paris, France

[d] CIMS, Hôtel-Dieu, Assistance Publique-Hôpitaux de Paris, 1 Parvis Notre Dame, 75004 Paris, France

[e] Insa Lyon France

[f] Diagnoform France

Corresponding Author:
Mrs. Hala NASSIF
IRMES, INSEP, 11 avenue du Tremblay, 75012 Paris, France
hala.nassif@insep.fr
Tel: 01.41.74.42.73 Fax: 01.41.74.41.75

We declare no conflict of interest

Word Count Abstract: 192

Word Count main text: 2542

Monitoring fitness levels and detecting implications for health on a large scale of the general population

Abstract

Objective

To analyze the physical fitness level of 31 133 French citizens aged between 8 and 60 years old and represent the performances through a bi-exponential model.

Methods

We collected data from 231 events that took place in French regions between 2006 and 2010 and analyzed participation and physical fitness using a simple series of tests. We assessed outcome measures in relation to age and BMI using Spearman Rho, a one way ANOVA and a bi-exponential model.

Results

Our major results showed higher performances for men and for subjects with normal BMI at all age groups except for the flexibility test. Body mass index is strongly correlated across all ages with physical fitness $p < 0.0001$. Those results are in accordance with the literature. Furthermore, through a bi-exponential model, a mean peak performance was identified at 26.32 years old for men and 22.18 years old for women.

Conclusion

Physical fitness assessment using simple tests is applicable on the general population and is correlated to age, BMI and health status. The application of a bi-exponential model offers a global approach to monitor public health.

Key words: physical fitness; physical activity; model; promotion

We declare no conflict of interest

Word Count Abstract: 192

Word Count main text: 2542

Introduction

Human species has been increasing in body size over the past two centuries. Interestingly, weight continues to increase in spite of height stability (Cole, 2003) (Fogel, 2004) (Floud *et al.*, 2011) . Physical fitness is one of the most important factors that determined the survival of our ancestors (O'Keefe *et al.*, 2010) and it is also an indicator of health status. Several epidemiological studies have measured fitness levels using different methodologies in order to understand the secular trends and their relation to health (Andreasi *et al.*, 2010)(Marques-Vidal *et al.*, 2010)(Nielsen & Andersen, 2003)(Sassen *et al.*, 2010). Despite the evidence of a strong inverse mortality gradient across fitness groups, with a 50% lower mortality rate for the highly fit group (Blair *et al.*, 2001) a better lipid profile and a decreased incidence of coronary heart disease (Sternfeld *et al.*, 1999), sedentary behavior and declining physical fitness are still serious public health threats across all ages.

We are witnessing a worldwide burden of metabolic risk factors with 1.46 billion adults overweight or obese affecting health expenditure through the cost of morbidity and mortality. A low percentage of children (23.8% boys / 15.4% girls) aged between 13 and 15 years old in 34 developing countries are meeting the 60 minutes exercise/day recommendations (Guthold *et al.*, 2010). This high level of sedentary behavior is observed in worldwide regions and patterns of physical activity and fitness are deteriorating (Guthold *et al.*, 2010). Also, European adolescents are not meeting the recommendations set to limit time viewing television to no more than 2 hours per day (Rey-López *et al.*, 2010). The physical inactivity pattern of children and adolescents is highly correlated with media availability, access to electronic offer and time spent television viewing, internet surfing, and playing computer or video games.

A number of international studies investigated the fitness level of children and adolescents on representative samples of the population (e g: HELENA, AVENA, EYHS…) (Moliner-Urdiales *et al.*, 2010)(Ortega *et al.*, 2005)(Powell *et al.*, 2009) and secular trends in the aerobic performance of children and adolescents have been evaluated in the developed world (Tomkinson *et al.*, 2003). However, to our knowledge there exist few studies reporting the physical fitness level of adolescents, adults and elderly through the same test.

The measurement of physical fitness is a challenging objective due to high variability and the presence of correlated factors (Tremblay *et al.*, 2010). For instance, total body fat, habitual physical activity and socioeconomic status have been independently correlated to physical fitness (Jiménez Pavón *et al.*, 2010).

The objective of the following study is to analyse the results of a French series of tests designed by the Athletic Track and Field Federation Ligue-Nord-Pas-de-Calais and performed on a large sample of the population between 2006 and 2010.

Methods

Sample preparation and origin

Advertising promotional campaigns in the region, via schools or organization took place prior to the date of the test. The schools, municipalities and major local representatives were aware of the coming event and encouraged all inhabitants of the region, children at school and workers to come and test their physical fitness. The events took place in 12 regions out of 22 in France metropolitan (Alsace, Aquitaine, Bretagne, Bourgogne, Champagne-Ardenne, Ile-de-France, Langedoc-Roussillon, Midi-Pyrénées, Nord-Pas-de-Calais, Pays de la Loire, Rhône-Alpes) and the recruitment was based on a voluntary basis.

Tests and Subjects:

The physical fitness series of test has been developed by the organizers of this event and validated in a previous study (Mouraby *et al.*, 2011). Indicators were age, Body Mass Index (BMI) (Weight (kg)/Height (cm) ^{2}), and fitness score on each test. Body Mass Index for children and adolescents was according to the French National Plan for Nutrition and Health (PNNS) scales. For adults a BMI < 18.5 was considered underweight (UW), BMI 18.5 to 24.9 Normal Weight (NW), BMI 25-29.9 Overweight (OW) and BMI > 30 was considered Obese (OB). All subjects performed the same series of tests named Diagnoform tonic ®, separate batteries of tests were designed for other age groups or subjects with health contraindications. All measurements were collected by trained staff and the reporting was supervised. We extracted anonymous data from the organizers of the events between 2006 and 2010.

Field site description

The event took place in large settings such as a schools' play ground or sports club gymnasiums. The organizers of the event prepared the site in advance and planned the process to welcome a large flow of people at the same time. A separate area was specifically set to fill in the results on the database, print result sheets and lead each participant to a nutritionist or physical educator present to give oral advice on health, physical activity and nutrition.

Description of Tests: (35-40mn workshop)

1. Non-progressive 20m shuttle run measures the maximum distance reached during a 3 minutes run (in meters). The subject is invited to run back and forth on a straight 20m line for 3 minutes. The supervisor counts the number of times the subject went back and forth and translates it to a measurement.
2. Standing broad jump test measures explosive strength (in centimeters). The subject jumps as far as possible with legs joined.
3. Repeated squat jump test measures explosive strength, elastic energy and coordination (in centimeters). The subject jumps 5 consecutive jumps with legs joined.
4. 4x10 meter shuttle run test measures speed and agility by recording the minimal time needed to complete the 40 meters course (in seconds).
5. Speed measures anaerobic capacity by running as fast as possible a 30 meters course (in seconds).
6. Flexibility test measures leniency and the capacity to reach as far as possibly down starting from standing position and maintaining the position for 3 seconds. Records are indexed: for placing hands flat on the ground = 5, fingers touch the ground = 4, fingers reach the ankle = 3, fingers reach the tibia = 2, fingers/hand reach the knees = 1
7. Pushups test measures muscular strength and endurance. Subject performs repetitions with knees on the ground, lowering body to a 90 degree elbow angle and then back up to the initial position.

Statistical Analysis

Descriptive analysis: Mean, standard deviation, Min and Max values for each test and according to age groups (children: 8 to 11, adolescents: 12 to 17 and adults 18 to 60) were calculated.

Comparisons: A one-way ANOVA has been used to test for statistical difference between age groups, weight categories and performances for each test.

Correlation: Spearman Rho correlation was calculated to measure the relationship between BMI and the different measures of tests.

Model: A bi-exponential model (Moore, 1975) (Berthelot *et al.*, 2011) was used to fit the progression-regression curve across all age groups for each of the speed test, standing broad Jump, 20 meter shuttle run and the repeated squat jump test.

$$\mathrm{P(t)} = a \times \left(1 - \mathrm{e}^{bt}\right) + c \times \left(1 - \mathrm{e}^{dt}\right)$$

The coefficients *a*, *b*, *c* and *d* are estimated using a least-square non-linear regression method with:

$$\begin{cases} a,c,d > 0 \\ b < 0 \end{cases}$$

Analysis was performed using MATLAB and SPSS, v.19.0 for WNDOWS; SPSS Inc, Chicago.

Results

Descriptive

The total number of recruited subjects was 31 133 for 8-60 years old. Children 8 to 11 n=6494 (20.85%), adolescents (12-17) n=19 496 (62.62%), and adults (18-60) n= 5143 (n=16.51%). The year 2008 was the year with the highest number of promotional campaign days and participants per campaign. The number of promotional campaign days between the years 2006-2010 with the corresponding number of participants per year is presented in **table 1**.

Underweight children and adolescents were 2.57% (boys) and 2.46 % (girls). Normal BMI was 78.32% (boys) and 80.88% (girls). Overweight children and adolescents were 14.42 % for boys, 12.90 % for girls. 4.68% boys and 3.66% girls were obese. Mean scores for the Diagnoform test across age groups are described in **table 2**.

Correlations

BMI and performance

Boys generally performed better than girls in all performances. Girls seem more flexible than boys across all ages and weight categories.

Adults in the normal weight for height category (BMI 18.5-24.9) performed longer distances in the *20m shuttle run* (Men: 621. 2 meters for Normal Weight (NW) versus 568. 8 meters for overweight (OW), Women: 516 meters for NW versus 467. 30 meters for OW) ; *standing broad jump* (Men: 213.9 cm NW versus 199,57 cm OW, Women: 160,73cm NW versus 142. 7 cm OW); *repeated squat jump* (Men: 1077.6 cm NW versus 1017,22 cm OW, Women: 797.1 cm NW versus 706.6 cm OW) and had the best records in respect to time for each of the *4*10m shuttle run* and *speed test*.

ANOVA analysis revealed a statistically significant difference $p < 0.0001$ between all groups in function of BMI category UW, NW, OW, OB.

Figure 1 and **Figure 2** represent the relationships between the BMI and the 7 fitness tests.

Age and performance

Spearman Rho correlations were small to medium between age and the physical tests for women $p < 0.0001$ and medium to strong correlation for men, but all significant $p < 0.0001$.

Performance increases with age until the ages 26-30 then we observe a decrease, demonstrating a progression regression curve that is represented in **Figure 3**.

The mean age peak performance for the speed, standing broad jump, 20m shuttle run and repeated squat jump fitness tests is 26.32 for men and 22.18 for women.

Discussion

This study analyzes the data collected from the Diagnoform® test in function of age, sex and BMI. The major results of the following study are the mean average performances of the sample and the application of progression-regression law on performance revealing a mean peak at 26.32 years old for males and 22.18 for women showing a greater precocity and earlier decline suggestive of determinants in biological development (Cole, 2003). We found that girls had a lower physical fitness performance rate at all ages compared to boys except for the flexibility test which is in accordance with the literature (Tomkinson *et al.*, 2003). In addition, overweight and obese subjects performed less well compared to their peers in the same age group and sex revealing the negative effect of increased adiposity on physical fitness.

Children and adolescents

In our study we observed that French adolescents performed similarly to their Spanish scholars in the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) (Moreno *et al.*, 2008) and AVENA (Alimentacion Valoracion del Estado Nutriocional en Adolescentes) (Moreno *et al.*, 2003) studies (Moliner-Urdiales *et al.*, 2010) specifically in the 4x10m shuttle run and the standing broad jump. Boys in the Diagnoform test (2006-2010) had a mean score of 11.3 seconds +/- 1.35 compared to 11.4 seconds +/- 0.9 in the AVENA study (2001-2002) and to 11.2 +/- 0.9 in the HELENA study (2006-2007). Girls had a mean score of 12.3 seconds +/- 1.3 in the Diagnoform test, 12.6 +/- 0.9 seconds in the AVENA study and 12.3 +/- 0.9 seconds in the HELENA study. For the standing broad jump in the Diagnoform sample the boys had a score of 174.7 +/- 35.2 cm approaching the results of the HELENA study at 176.5 +/-27.6 cm. Girls had a score similar to the AVENA study with 147.17 +/- 26.44 and 149.0 +/- 22.9 cm respectively. Although many factors such as physical activity, nutritional status, environmental factors and protocol details might be responsible for variability we observe a similar trend between the adolescents in the three mentioned studies.

The development of physical fitness performance with age

Several studies identified the age of peak performance. The relationship between age and physical ability is a major characteristic of human development (Schulz & Curnow, 1988). All individuals are subject to a development phase then undergo a decline during ageing that can be easily described through a bi-exponential model (Berthelot *et al.*, 2011). The general population is now subject to sedentary behavior. Thus the measurement of fitness is necessary to evaluate the physical capacity and capability of coping. Moore's equation offers a simple model that clearly depicts the development phase of children, adolescents, young adults and the declining phase of older adults and elderly. Adults in our sample (18-

60 years old) performed higher scores than children and adolescents in all tests. Furthermore, we specifically observed that adults aged 40 to 60 years old performed better than expected given their age. In fact, physical fitness is expected to decline with age if not maintained with a habitual physical activity (Powell *et al.*, 2009) (Lakoski *et al.*, 2011) (Kampert *et al.*, 1996). However, given the lack of detailed information on their habitual physical activity we are unable to report correlations that might infer this conclusion. We assume that the sample in our study are more aware and competent in the physical fitness domains such as coordination, endurance and flexibility compared to how physical fitness is valued and skilled in older people (Amesberger *et al.*, 2011).

Physical fitness measurement: a promotional tool?

Measuring physical fitness as a health indicator similar to body mass index (BMI) and waist circumference (WC) constitutes an essential variable to be monitored in order to analyze and understand the secular trends and the evolution of risks for metabolic and cardiovascular disease (Erikssen, 2001). Nevertheless, the correlation between the measurement at a given time and the follow-up process has not shown to reverse habits or modify behavior to increase physical fitness and daily energy expenditure. In fact, physical fitness testing and awareness is efficient if part of a larger multi-dimensional health promotion campaign that takes into consideration the nature and amount of habitual physical activity, the environment and the barriers (Naughton *et al.*, 2006).

Assessing relevant health indicators using simple tools such as the physical fitness series of test offers an essential component of health impact assessment. Although, some authors discussed the inconclusive negative effects of large scale fitness testing (Wrench & Garret, 2008). Our study reinforces its importance and suggests implementing it following an intervention on habitual physical activity in order to demonstrate that the small changes in fitness are associated with a change in health (Blair *et al.*, 2001).

Perspectives

This series of tests seems an important initiative in the field of prevention and physical activity promotion in the French regions. The consequences of physical deconditioning can be mitigated with a well designed risk reduction strategy targeting the more in need while maintaining a critical approach in the understanding of the secular increase in the obesity and the sedentary behavior (Holtermann *et al.*, 2011)(Ross & Bradshaw, 2009). Multilevel programs such as ICAPS (Simon *et al.*, 2006) in the eastern French region proved to be efficient in improving physical activity in adolescents. Other proposed effective ways to help in reversing the deconditioning process and in preventing undesirable effects is active transportation which can help in increasing physical fitness. For instance a 20 to 30 min cycling transportation to school or work may increase aerobic power and thus result in higher levels of fitness (Andersen *et al.*, 2009).

Successful physical activity interventions target intrapersonal, social, physical environmental and policy changes. This series of tests can be considered an important health indicator and might be able to complement strategies as a promotional tool. Its application on a representative population across all ages will open the possibility of creating quintiles, healthy fitness zones and analyze correlations with different life-style factors. Thereafter, evaluating changes that differ from normal zones would offer a new tool for public health monitoring.

Study limitations and strengths

The strengths in the following study are (1) the applicability of the same series of tests on a large French population across 4 years (2) the high number of participants during the promotional days and (3) the possibility of modeling the data using a new approach that offers a global transversal picture of the fitness level in a population according to performance in the series of tests. The major limitations in this study are the non-normal distribution of age, the minor representation of the elderly and the insufficient details on the physical activity habits of the participants.

Conclusion

Our study reports the physical fitness level of a large French sample and uses a bi-exponential model to show the consistency in depicting the progression- regression of fitness levels. Its applicability as an evaluation and monitoring tool might offer new insights in the field of health promotion.

Acknowledgments

We thank the INSEP teams, and the Ligue Nord Pas De Calais for their full support. We thank Mr. Stéphane Len, Ms. Marion Guillaume, Mr. Geoffroy Berthelot, Ms.Nour El Helou, Mrs. Karine Schaal and Mr. Andy Marc for their helpful input during the analysis and the review of the article.

References

Amesberger, G., Finkenzeller, T., Würth, S. & Müller, E. (2011). Physical self-concept and physical fitness in elderly individuals. *Scand J Med Sci Sports*, *21 Suppl 1*, 83-90.

Andersen, L. B., Lawlor, D. A., Cooper, A. R., Froberg, K. & Anderssen, S.A. (2009). Physical fitness in relation to transport to school in adolescents: the Danish youth and sports study. *Scand J Med Sci Sports*, *19*, 406-11.

Andreasi, V., Michelin, E., Rinaldi, A. E. M. & Burini, R.C. (2010). Physical fitness and associations with anthropometric measurements in 7 to 15-year-old school children. *J Pediatr (Rio J)*, *86*, 497-502.

Berthelot, G., Len, S., Hellard, P., Tafflet, M., Guillaume, M., Vollmer, J., Gager, B., Quinquis, L., Marc, A. & Toussaint, J. (2011). Exponential growth combined with exponential decline explains lifetime performance evolution in individual and human species. *Age (Dordr)*, , .

Blair, S. N., Cheng, Y. & Holder, J.S. (2001). Is physical activity or physical fitness more important in defining health benefits?. *Medicine & Science in Sports & Exercise*, *33*, S379-S399.

Cole, T. J. (2003). The secular trend in human physical growth: a biological view. *Econ Hum Biol*, *1*, 161-8.

Erikssen, G. (2001). Physical fitness and changes in mortality: the survival of the fittest. *Sports Med*, *31*, 571-6.

Floud, R., Fogel, R., Harris, B. & Hong, S. (2011). The changing body: Health, Nutrition, and Human Development in the Western World since 1700. Cambridge University Press.

Fogel, R. (2004). The escape from hunger and premature death, 1700-2100. *Cambridge Universtity Press*, *Cambridge*, .

Guthold, R., Cowan, M. J., Autenrieth, C. S., Kann, L. & Riley, L.M. (2010). Physical activity and sedentary behavior among schoolchildren: a 34-country comparison. *J Pediatr*, *157*, 43-49.e1.

Holtermann, A., Hansen, J. V., Burr, H., Søgaard, K. & Sjøgaard, G. (2011). The health paradox of occupational and leisure-time physical activity. *Br J Sports Med*, , .

Jiménez Pavón, D., Ortega, F. P., Ruiz, J. R., España Romero, V., García Artero, E., Moliner Urdiales, D., Gómez Martínez, S., Vicente Rodríguez, G., Manios, Y., Béghin, L., Répasy, J., Sjöstrom, M., Moreno, L. A., González Gross, M., Castillo, M. J. (2010). Socioeconomic status influences physical fitness in European adolescents independently of body fat and physical activity: the HELENA study. *Nutr Hosp*, *25*, 311-6.

Kampert, J. B., Blair, S. N., Barlow, C. E. & Kohl, H.W.3. (1996). Physical activity, physical fitness, and all-cause and cancer mortality: a prospective study of men and women. *Ann Epidemiol*, *6*, 452-7.

Lakoski, S. G., Barlow, C. E., Farrell, S. W., Berry, J. D., Morrow, J. R. J. & Haskell, W.L. (2011). Impact of body mass index, physical activity, and other clinical factors on cardiorespiratory fitness (from the Cooper Center longitudinal study). *Am J Cardiol*, *108*, 34-9.

Marques-Vidal, P., Marcelino, G., Ravasco, P., Oliveira, J. M. & Paccaud, F. (2010). Increased body fat is independently and negatively related with cardiorespiratory fitness levels in children and adolescents with normal weight. *Eur J Cardiovasc Prev Rehabil*, *17*, 649-54.

Moliner-Urdiales, D., Ruiz, J. R., Ortega, F. B., Jiménez-Pavón, D., Vicente-Rodriguez, G., Rey-López, J. P., Martínez-Gómez, D., Casajús, J. A., Mesana, M. I., Marcos, A., Noriega-Borge, M. J., Sjöström, M., Castillo, M. J., Moreno, L. A. (2010). Secular trends in health-related physical fitness in Spanish adolescents: the AVENA and HELENA studies. *J Sci Med Sport*, *13*, 584-8.

Moore, D. H. 2. (1975). A study of age group track and field records to relate age and running speed. *Nature*, *253*, 264-5.

Moreno, L. A., De Henauw, S., González-Gross, M., Kersting, M., Molnár, D., Gottrand, F., Barrios, L., Sjöström, M., Manios, Y., Gilbert, C. C., Leclercq, C., Widhalm, K., Kafatos, A., Marcos, A. (2008). Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. *Int J Obes (Lond)*, *32 Suppl 5*, S4-11.

Moreno, L. A., Joyanes, M., Mesana, M. I., González-Gross, M., Gil, C. M., Sarría, A., Gutierrez, A., Garaulet, M., Perez-Prieto, R., Bueno, M., Marcos, A. (2003). Harmonization of anthropometric measurements for a multicenter nutrition survey in Spanish adolescents. *Nutrition*, *19*, 481-6.

Mouraby, R., Tafflet, M., Nassif, H., Toussaint, J. F. & Desgorces, F.D. (2011). Fiabilité et validation de la batterie de tests physiques Diagnoform. *Science et Sports*, , .

Naughton, G. A., Carlson, J. S. & Greene, D.A. (2006). A challenge to fitness testing in primary schools. *J Sci Med Sport*, *9*, 40-5.

Nielsen, G. A. & Andersen, L.B. (2003). The association between high blood pressure, physical fitness, and body mass index in adolescents. *Prev Med*, *36*, 229-34.

O'Keefe, J. H., Vogel, R., Lavie, C. J. & Cordain, L. (2010). Achieving hunter-gatherer fitness in the 21(st) century: back to the future. *Am J Med*, *123*, 1082-6.

Ortega, F. B., Ruiz, J. R., Castillo, M. J., Moreno, L. A., González-Gross, M., Wärnberg, J., Gutiérrez, A. (2005). [Low level of physical fitness in Spanish adolescents. Relevance for future cardiovascular health (AVENA study)]. *Rev Esp Cardiol*, *58*, 898-909.

Powell, K. E., Roberts, A. M., Ross, J. G., Phillips, M. A. C., Ujamaa, D. A. & Zhou, M. (2009). Low physical fitness among fifth- and seventh-grade students, Georgia, 2006. *Am J Prev Med*, *36*, 304-10.

Rey-López, J. P., Vicente-Rodriguez, G., Ortega, F. B., Ruiz, J. R., Martinez-Gómez, D., De Henauw, S., Manios, Y., Molnar, D., Polito, A., Verloigne, M., Castillo, M. J., Sjöström, M., De Bourdeaudhuij, I., Moreno, L. A. (2010). Sedentary patterns and media availability in European adolescents: The HELENA study. *Prev Med*, *51*, 50-5.

Ross, R. & Bradshaw, A.J. (2009). The future of obesity reduction: beyond weight loss. *Nat Rev Endocrinol*, *5*, 319-25.

Sassen, B., Kok, G., Schaalma, H., Kiers, H. & Vanhees, L. (2010). Cardiovascular risk profile: cross-sectional analysis of motivational determinants, physical fitness and physical activity. *BMC Public Health*, *10*, 592.

Schulz, R. & Curnow, C. (1988). Peak performance and age among superathletes: track and field, swimming, baseball, tennis, and golf. *J Gerontol*, *43*, P113-20.

Simon, C., Wagner, A., Platat, C., Arveiler, D., Schweitzer, B., Schlienger, J. L. & Triby, E. (2006). ICAPS: a multilevel program to improve physical activity in adolescents. *Diabetes Metab*, *32*, 41-9.

Sternfeld, B., Sidney, S., Jacobs, D. R. J., Sadler, M. C., Haskell, W. L. & Schreiner, P.J. (1999). Seven-year changes in physical fitness, physical activity, and lipid profile in the CARDIA study. Coronary Artery Risk Development in Young Adults. *Ann Epidemiol*, *9*, 25-33.

Tomkinson, G. R., Léger, L. A., Olds, T. S. & Cazorla, G. (2003). Secular trends in the performance of children and adolescents (1980-2000): an analysis of 55 studies of the 20m shuttle run test in 11 countries. *Sports Med*, *33*, 285-300.

Tremblay, M. S., Shields, M., Laviolette, M., Craig, C. L., Janssen, I. & Gorber, S.C. (2010). Fitness of Canadian children and youth: results from the 2007-2009 Canadian Health Measures Survey. *Health Rep*, *21*, 7-20.

Wrench, A. & Garret, R. (2008). Pleasure and pain: experiences of fitness testing. *European Physical Education Review*, *4*, 325-346.

Figure and table legends

Table 1: The distribution of promotional campaign days and participants from 2006 till 2010. The campaigns took place in 12 out of 22 regions in France (Alsace, Aquitaine, Bretagne, Bourgogne, Champagne-Ardenne, Ile-de-France, Langedoc-Roussillon, Midi-Pyrénées, Nord-Pas-de-Calais, Pays de la Loire, Rhône-Alpes).

Table 2: Representation of mean scores according to gender and age group. SD: Standard Deviation, Min: Minimum value, Max: Maximum value.

Figure 1: Mean performance in children and adolescents according to BMI categories. UW: underweight, NW: normal weight, OW: overweight, Ob: Obese. Bars represent +/- SD. P value < 0.0001 between categories.

Figure 2: Mean performance in adults according to BMI categories. UW: underweight, NW: normal weight, OW: overweight, Ob: Obese. Bars represent +-/ SD. P value < 0.0001 between categories.

Figure 3: Bi-exponential model fit on the mean performances of 4 tests: the standing broad jump test (SBJ) in cm, the repeated squat jump test (RSJ) in cm, the speed test (Sp) in $m.s^{-1}$and the 20m shuttle run test (20m run) in $m.s^{-1}$for men and women at all ages. Peak age calculated is 30.9 years old R^2= 0.84 for men and 26.1 years R^2= 0.86 for women in the SBJ test. For the RSJ test: 30.9 years old R^2=0.85 for men and 26 years R^2= 0.78 for women. For the Sp test: 24.9 years R^2=0.86 for men and 21.2 years R^2= 0.87 for women. For the 20 m run test: 22.5 years R^2= 0.77 for men and 17.7 years R^2=0.71 for women.

	MALES 4-80		FEMALES 4-72	
Year	Promotional Campaign days	Participants	Promotional Campaign days	Participants
2006	8	919	9	1004
2007	44	2754	41	2272
2008	80	6598	83	6712
2009	68	3465	73	3615
2010	27	2190	25	1829
Total	227	15917	231	15432

Table 1: Distribution of promotional campaign days and participants between 2006 and 2010. The campaigns took place in 12 out of 22 regions in France (Alsace, Aquitaine, Bretagne, Bourgogne, Champagne-Ardenne, Ile-de-France, Langedoc-Roussillon, Midi-Pyrénées, Nord-Pas-de-Calais, Pays de la Loire, Rhône-Alpes).

Age	Gender	n	Standing Broad Jump (cm) Mean	SD	Min	Max	4*10m Shuttle Run (sec) Mean	SD	Min	Max	20m shuttle run (meters) Mean	SD	Min	Max	Repeated Squat Jump (cm) Mean	SD	Min	Max
8 to 11	Boys	3267	143.12	23.24	50	300	12.28	1.12	8.02	21.82	519.61	62.36	80	950	702.86	115.82	230	1740
	Girls	3227	130.64	22.38	50	250	12.96	1.18	9.37	24.00	490.24	55.77	180	900	653.73	108.76	180	1123
12 to 17	Boys	9786	174.74	35.18	45	305	11.33	1.35	8.1	38.25	566.99	75.77	200	1000	858.46	180.94	300	1900
	Girls	9710	147.17	26.44	30	400	12.27	1.28	8.5	40.00	512.2	60.58	120	980	719.22	122.23	280	1224
18 to 39	Men	2172	213.26	30.48	90	400	10.4	1.04	7.91	20.5	618.27	69.68	300	1000	1075.93	153.25	420	1610
	Women	2001	159.79	27.16	49	255	11.84	1.25	9.02	26.00	515.64	68.02	200	800	791.83	130.66	160	1260
40 to 60	Men	557	195.21	28.64	80	265	11.09	1.2	9.18	20.16	566.19	72.21	200	760	986.14	147.05	300	1360
	Women	413	150.15	28.89	60	250	12.57	1.62	9.69	24.74	482.05	68.57	240	700	750.85	141.1	200	1620

Age	Gender	n	Speed (sec) Mean	SD	Min	Max	Push-Ups (reps) Mean	SD	Min	Max	Flexibility Index (1-5) Mean	SD	Min	Max
8 to 11	Boys	3267	5.84	1	4	45.74	26.12	15.93	0	126	3.29	0.89	1	5
	Girls	3227	6.24	0.77	4	19.00	20.00	12.35	0	100	3.57	0.93	1	5
12 to 17	Boys	9786	5.33	0.72	3.33	12.53	34.27	19.02	0	160	3.46	0.92	0	5
	Girls	9710	5.81	0.69	3.67	16.13	20.85	12.63	0	148	3.86	0.95	0	5
18 to 39	Men	2172	4.7	0.52	3.63	10.15	46.78	20.55	0	150	3.76	0.9	1	5
	Women	2001	5.63	0.75	4	12.97	25.97	14.81	0	110	4.13	0.89	1	5
40 to 60	Men	557	5.13	0.67	4.05	12.37	40.39	19.97	0	160	3.73	0.92	1	5
	Women	413	6.1	0.88	4.33	11.79	27.5	16.2	0	150	4.24	0.88	0	5

Table 2: Representation of mean scores according to gender and age group. SD: Standard Deviation, Min: Minimum value, Max: Maximum value.

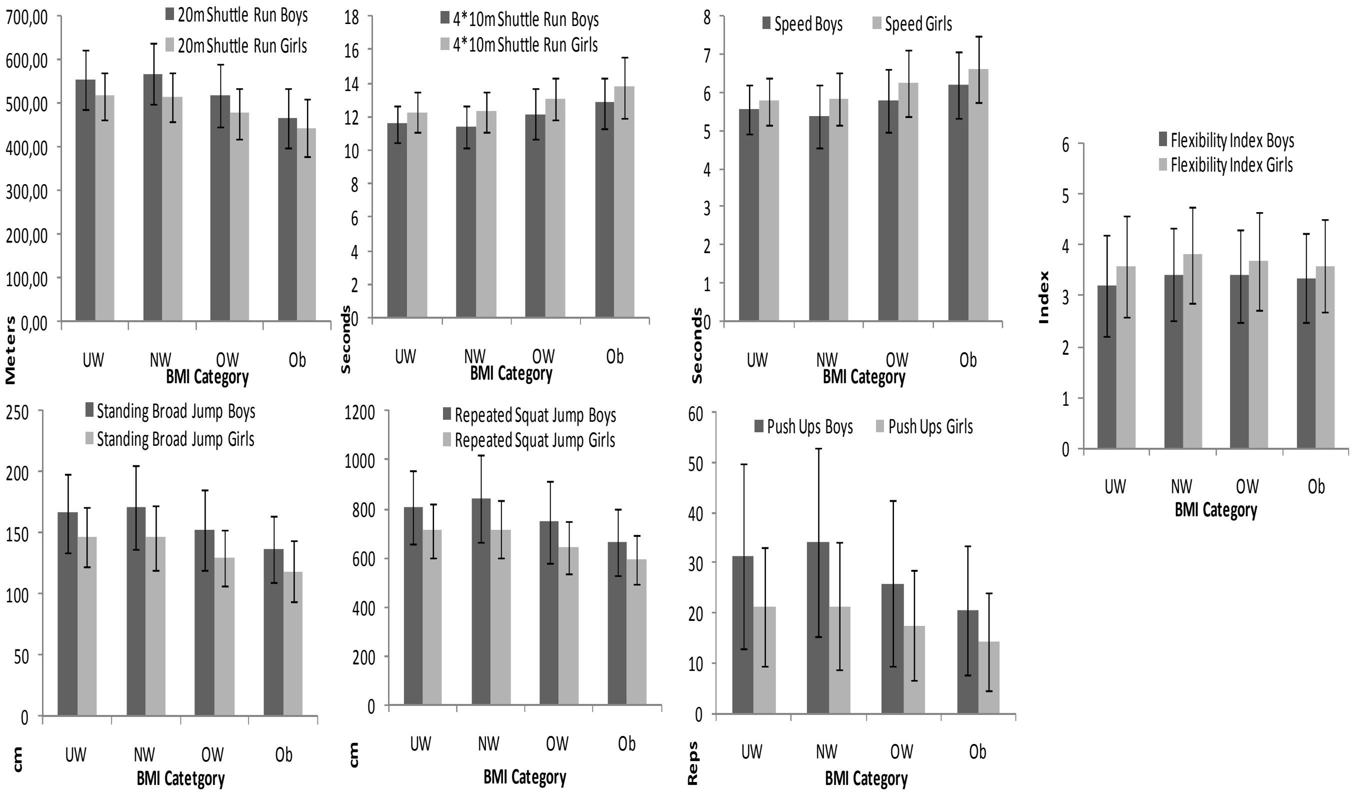

Figure 1: Mean performance in children and adolescents according to BMI categories. UW: underweight, NW: normal weight, OW: overweight, Ob: Obese. Bars represent +/- SD. P value < 0.0001 between categories.

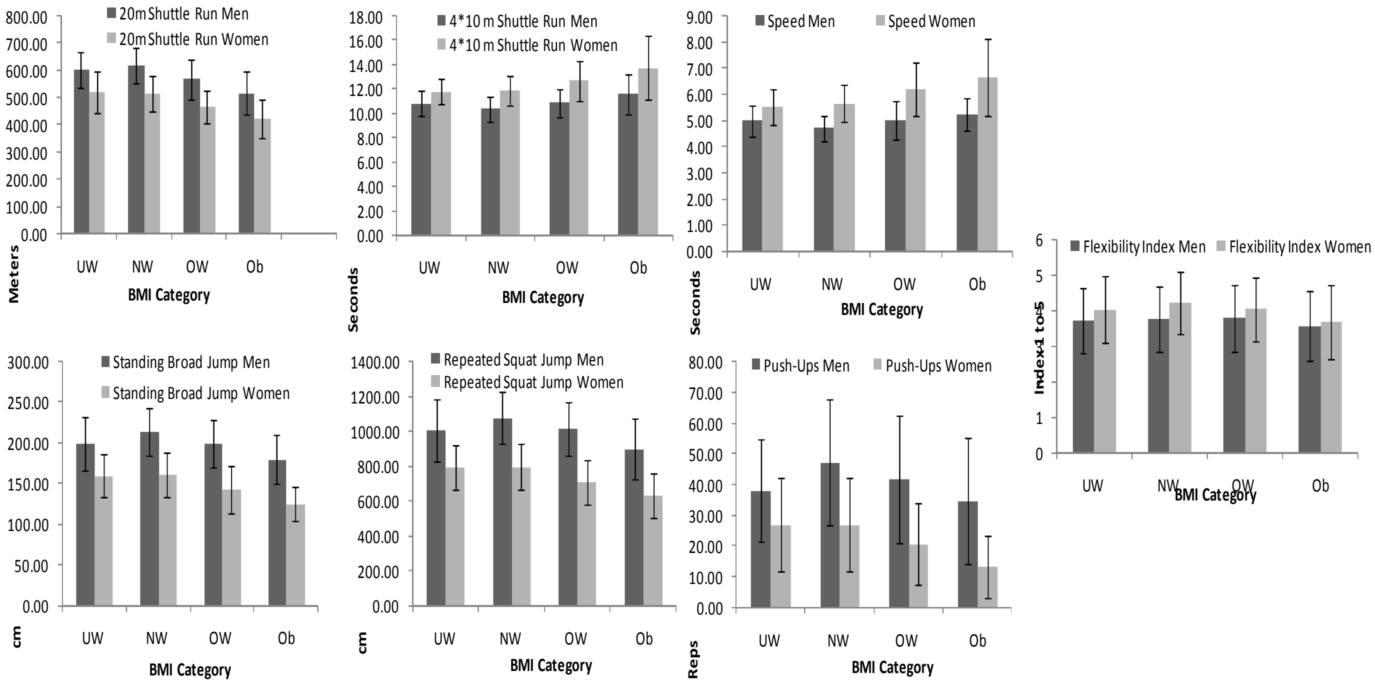

Figure 2: Mean performance in adults according to BMI categories. UW: underweight, NW: normal weight, OW: overweight, Ob: Obese. Bars represent +-/ SD. P value < 0.0001 between categories.

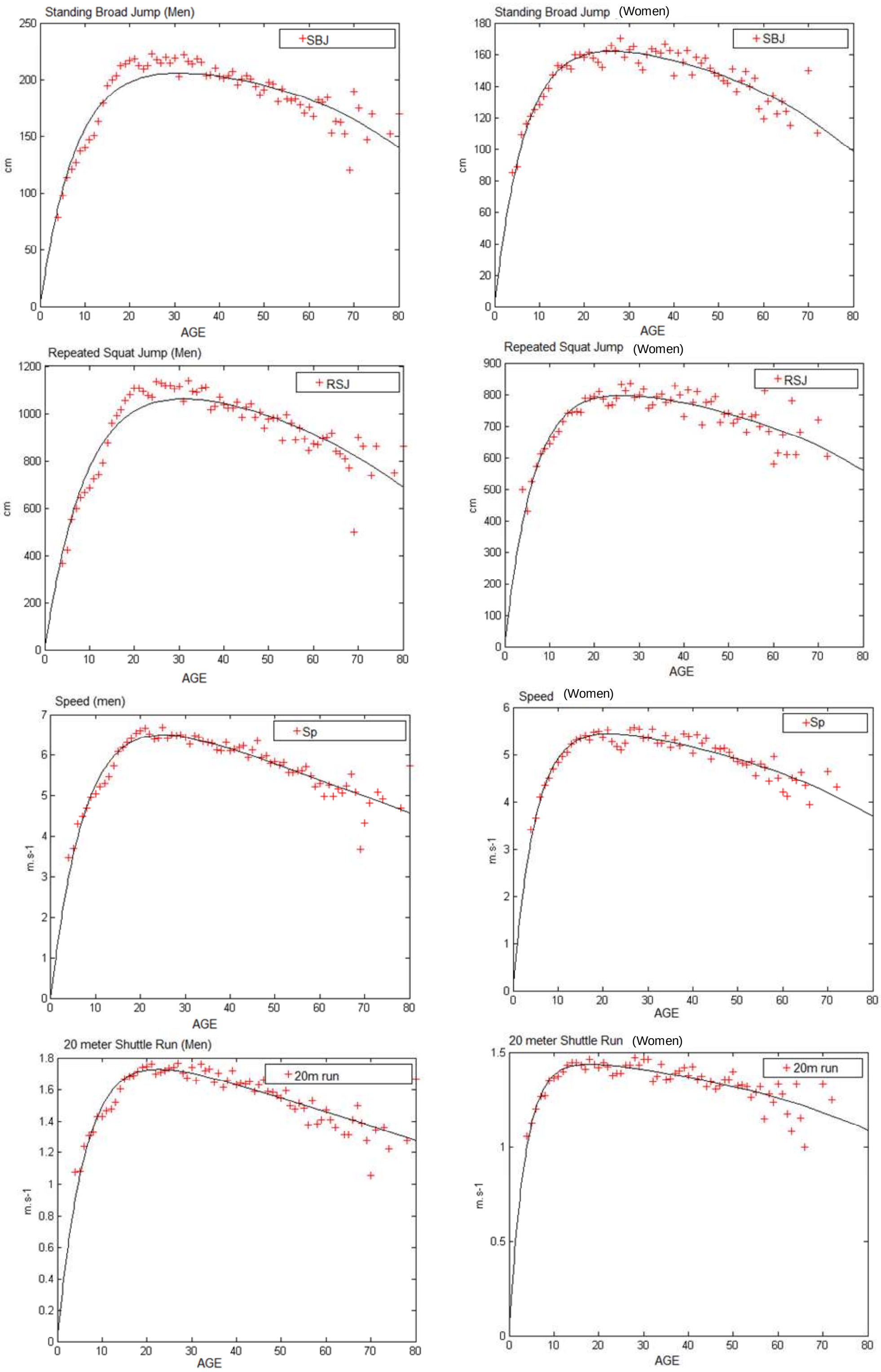

Figure 3: Bi-exponential model fit on the mean performances of 4 tests: the standing broad jump test (SBJ) in cm, the repeated squat jump test (RSJ) in cm, the speed test (Sp) in $m.s^{-1}$ and the 20m shuttle run test (20m run) in $m.s^{-1}$ for men and women at all ages. Peak age calculated is 30.9 years old R^2= 0.84 for men and 26.1 years R^2= 0.86 for women in the SBJ test. For the RSJ test: 30.9 years old R^2=0.85 for men and 26 years R^2= 0.78 for women. For the Sp test: 24.9 years R^2=0.86 for men and 21.2 years R^2= 0.87 for women. For the 20 m run test: 22.5 years R^2= 0.77 for men and 17.7 years R^2=0.71 for women.