

Physics of Karate project. Measurement Human body barycentre



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Abstract

In this paper it is shown a simple didactic experiment for position measurement of human body barycentre. This method is very easy to use with student of High School. The experimental activities of measurement of human body barycentre position has been performed in the Physics of Karate Project at "Fermi" High School of Ragusa, thanks to the collaborations of the Physics and Astronomy Department of Catania and Dojo Karate-do Shotokan.

Keywords: Physics Education, Classical Mechanics teaching, Art Martial, Karate

Resumen

En este artículo se muestra un sencillo experimento didáctico para la medición de posición del centro de gravedad del cuerpo humano. Este método es muy fácil para usarse con estudiantes de secundaria. Las actividades experimentales de medición de la posición del centro de gravedad del cuerpo humano se ha realizado en la Física del Proyecto de Karate en "Fermi" Escuela Superior de Ragusa, gracias a la colaboración del Departamento de Física y Astronomía de Catania y Dojo de Karate-do Shotokan.

Palabras clave: Enseñanza de la Física, Enseñanza de la Mecánica Clásica, Artes Marciales, Karate.

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I. INTRODUCTION

For the Eastern culture, the psico-physics vital energy's centre of human body (*ki* in Japanese) is located in a point said *dantian* (*Tanden* in Japanese or *Tan T'ien* in Chinese). It is sets in the abdomen (*hara* in Japanese) located about three finger widths below and two finger widths behind the navel. This point is very importance for all the actions that human can do in its life. In all the martial arts every actions must be executed bringing the attention to this area of the body. A fundamental role in the management of the *dantian* is the breathing action made by using the diaphragm and the abdominal muscles. A karateka projects all the mental, physical and psychical energy in a single explosive focus emits a short exhalation said *ki-ai* (literally: union of the vital energy). The *dantian* and the *ki-ai* play a fundamental psychological role in obtaining the maximum concentration of the karateka in actions. They, besides, allows that the whole body of the karateka to participate in reaching the maximum result in the final action.

II. HUMAN BODY BARYCENTRE

However, the dantian doesn't have only a psychological value, it is the physical center of gravity of the human body. A simple didactic experiment for position measurement of human body barycentre needed two bathroom scales, a table and a tape measure, schematically arranged as shown in Fig. 1. [1, 2]

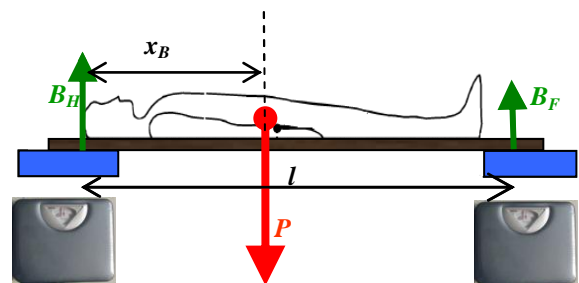


FIGURE 1. Schematic representation of position measurement of human body barycentre (see text). [1]

The barycentre position can be determined making use of the translation and rotation equilibrium condition

$$\begin{cases} P = B_H + B_F \\ P \cdot x_B = B_F \cdot l \end{cases} \quad (1)$$

where B_H and B_F are, respectively, the head and the feet reaction force of bathroom scales, P is the person's weight, l is the distance among the bathroom scales support centres and x_B is the barycentre. In the rotation equilibrium condition we have set the head bathroom scales the centre of rotation. From Eqs. (1) we can easily obtain

$$x_B = \frac{B_F \cdot l}{B_H + B_F} \quad (2)$$

III. MEASUREMENT OF HUMAN BODY BARYCENTRE IN PHYSICS OF KARATE PROJECT

The experimental activities of measurement of human body barycentre position has been performed in the Physics of Karate Project [3, 4]. The Physics of Karate course is a initiative promotes innovation in science teaching and learning through the study of the laws of Physics applicable to karate techniques, it began in the 2007/2008 scholastic year in the "Q. Cataudella" High School of Scicli, a village near Ragusa (Sicily/Italy) and thereafter at "Fermi" High School of Ragusa, thanks to the collaborations of the Physics and Astronomy Department of Catania and Dojo Karate-do Shotokan club of Scicli and Ragusa directed by Master Antonino Gianni. The aim of the project is to develop in students of High Secondary School critical attitudes by identifying and experimentally checking laws and principles of Physics involved in the actions of the human body and to teach Physics not simply as a school subject that "has to be learnt", but as a powerful research tool that allows us to know and understand the laws that regulate nature. The project has had recognitions of worth both national and international for the teaching of the physics in the high school and got in 2009 the STELLA (Science Teaching in a Lifelong Learning Approach) European quality certification and it was selected between the best four Italian learning science practices for eBook "Science Education in European Schools -Selected Practices from the STELLA Catalogue". [5]

During the carrying out of the courses of "Physics of Karate", in 2007-2010 years, the students have measured both the their and the Dojo Karate-do Shotokan karateka human body barycentre position. Experimentally occurred that this point falls really in the zone of the dantian, in fact, in all the analyzed people the barycentre is found some centimeters under the navel.

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FIGURE 2. The "E. Fermi" High School of Ragusa students measure the human body barycentre position.

To compare the barycentre position of people, since each has a different height, the barycentre position is calculated in percentage of the height:

$$x_{B\%} = \frac{x_B}{h} \cdot 100. \quad (3)$$

The diagram of Fig. 3 show the distribution of the barycentre in a sample of eighty four people, forty five females and thirty nine males. Particularly the sample was so composed as shown in the table I.

TABLE I. Number of examined people divided between males and females and for the age (see text).

Females		Males	
age	number	age	number
14	1	14	5
15	7	15	1
16	8	16	7
17	19	17	6
18	10	18	10
19	0	19	2
20	0	20	2
over 20	0	over 20	4
total	45	total	37

Analyzing the measures we have obtained that the human body barycentre position is to 44.2% of the height measured from the head, with standard deviation $\sigma = 1.4\%$ and standard error $es = 0.2\%$.

This experimental value obtained confirm the location of *dantian* in the oriental culture, in fact, it is really around three finger widths below of navel.

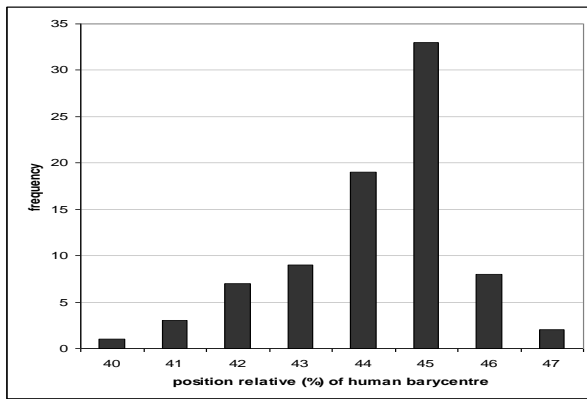


FIGURE 3. Histogram of the human body barycentre experimental distribution.

We have also obtained a very light tendency, even if it is not significant, of the women to have a lower barycentre 44.4% ($\sigma = 1.5\%$, $es = 0.2\%$), comparing to the males one at 44.1% ($\sigma = 1.3\%$, $es = 0.2\%$), what could agree with the different skeletal-muscular structure between male and female. In fact, the woman have an average distribution of the body mass [6, 7] more in the legs than in the bust, that allows the natural predisposition of the woman to pregnancy support.

IV. THE BARYCENTRE AND KARATE

In all the martial arts, to know how manage the proper barycentre is very important, since it is the point in which the whole mass and the weight of the human body are assembled. For equilibrium, a karateka always has to do so that its barycentre falls inside the base of support both when it stirs for performing a technique and is when it strikes. For dynamic action a karateka has to focus its attention to move its barycentre to move everything of its body.

This way when a karateka jumps, a lot of times it is not necessary to lift notably its barycentre but only the legs, for this motive it is important to train himself to lift the more possible the legs bringing them the nearest possible to the chest.

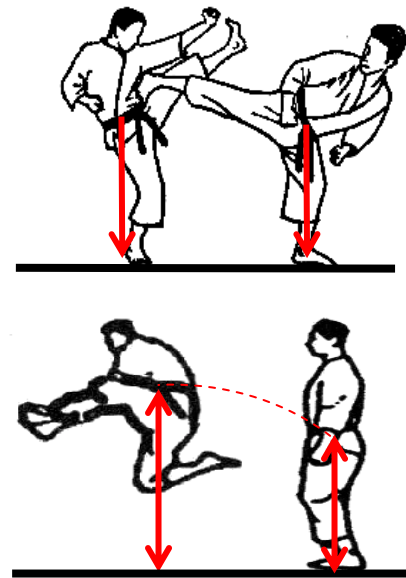
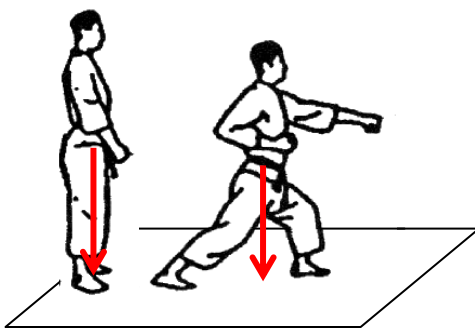


FIGURE 4. From up to the down, projection of the barycentre in the base of support in an inclined fist in advancement (oi-tsuki), in an inclined kick back (ushiro-gheri kekomi) and in a flying kick in before (mae-tobi-gheri) [7]

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REFERENCES

- [1] Gianino, C., Immé, J., *Physics of Karate. As to study Physics practising Karate*, Il Nuovo Cimento **125**, 765-774 (2010).
- [2] Glenn Elert and his students, *Center of Mass of a Human*, The Physics Factbook, < <http://hypertextbook.com/facts/2006/centerofmass.shtml> >, visited in May 2011
- [3] Gianino, C., *Physics of Karate. Kinematics analysis of karate techniques by a digital movie camera*, Lat. Am. J. Phys. Educ. **4**, 32-34 (2010).
- [4] *Physics of Karate Project*, visited in May 2011 < <http://fisicadelkarate.altervista.org> >
- [5] eBook STELLA, *Science Education in European Schools – Selected Practices from the STELLA Catalogue*, visited in May 2011 < http://www.stella-science.eu/pool_good_practices.php >
- [6] Zatsiorsky, V. M. and others, *Methods of determining mass-inertial characteristics of human body segment*, in G. G. Chernyi S. A. Regirer, Contemporary Problems of Biomechanics, Moscow/Boca Raton: Mir Publishers/CRC Press, (1990), pp. 272-291.

[7] de Leva, P., *Adjustments to Zatsiorsky-Seluyanov's segment inertia parameters*, Journal of Biomechanics **29**, 1223-1230 (1996).

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[8] Sivieri, L., *Dispensa RenBuKai*, Karate Ferrara, visited in May 2011 < <http://www.renbukai.it/tecnica.html> >