

Translating exercise biology into the Venezuelan medical education and health care system.

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Abstract. In the absence of pharmacological agents, physical exercise was widely used by physicians in the late 19th century to treat a number of maladies. In the 1950's, epidemiological evidence suggested an association between physical activity and health, and increased interest in clinical exercise biology. By the 1990's, sufficient research data was accumulated on the benefits of exercise, such that North American medical associations, government agencies, and the World Health Organization have published guidelines on exercise for public and clinical populations. Despite this, leaders in medical education have remained reluctant to incorporate exercise biology into the core medical curriculum, or to systematically implement it in graduate medical education. This work reviews Venezuelan exercise biology literature, and its medical applications. Venezuelan scientists and clinicians have invested efforts in cardiopulmonary exercise testing, skeletal muscle adaptations to training and exercise cardiovascular pharmacology in patients, sedentary subjects and athletes. It is suggested here, that there is a need to develop education and research programs in basic and clinical exercise biology in the formal training of medical students, physicians in residency programs, and allied health care professionals. Tentative steps to initiate this process are proposed.

Trasladando la biología del ejercicio a la educación médica y al sistema de cuidado de salud venezolano.

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Palabras clave: Biología del ejercicio, fisiología del ejercicio, actividad física, educación médica, historia de la medicina, política de salud.

Abstract. En la ausencia de agentes farmacológicos, el ejercicio físico fue ampliamente usado por médicos a finales del siglo 19 para tratar numerosas enfermedades. Durante el siglo 20, en la década de los 50's, la evidencia epidemiológica ya sugería una asociación entre la actividad física y la salud, y comenzaba un incremento en el interés en la biología del ejercicio con aplicación clínica. Ya en la década de los 90's, suficiente investigación fue acumulada indicando el beneficio del ejercicio, en Norteamérica ya asociaciones de medicina, entes gubernamentales y la Organización Mundial de la Salud publicaron guías sobre ejercicio para poblaciones clínicas y público en general. No obstante de esto, los dirigentes de educación médica han permanecido reacios a incorporar la biología del ejercicio al pñsum médico curricular, o a implementarlo sistemáticamente en la educación médica de postgrado. Este manuscrito revisa la trayectoria de la biología del ejercicio en Venezuela y sus aplicaciones médicas. Científicos y clínicos venezolanos han hecho contribuciones en áreas tales como pruebas de evaluación cardiopulmonar, adaptaciones de músculo esquelético al enfrentamiento físico y en farmacología cardiovascular en ejercicio en pacientes, sujetos sedentarios y atletas. Se sugiere que hay la necesidad de desarrollar programas de educación e investigación en biología del ejercicio con el fin de incorporar estos conocimientos en la formación del estudiante de medicina, médicos residentes y profesionales aliados al sistema de salud. Se propone una serie de pasos tentativos para iniciar este proceso.

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EXERCISE BIOLOGY AND HEALTH

Exercise biology studies the acute and chronic (i.e., training) effects of exercise on body systems, tissues, cellular and molecular function. Its origins merged medicine, physical education and physiology. By the late 19th century, manuscripts (1) and books (2) were written on the subject. In this period, physical exercise was widely used by physicians to treat a number of maladies, perhaps, because of the lack of pharmacological agents. However, the ad-

vent of the latter, and the reforms in medical education induced by the Abraham Flexner report (3), may have blunted the progress in clinical exercise biology. Meanwhile, basic exercise biology gradually flourished and, in 1921, Nobel prizes were awarded to Europeans Archibald Hill (British physiologist) and Otto Meyerhoff (German biochemist) for their work in muscle heat production, energetics, and lactic acid production in contracting skeletal muscle.

In the early 1950's, interest in clinical exercise biology gradually increased with

the publication of epidemiological evidence suggesting an association between physical activity and health (4). By the 1970's, sufficient research data and clinical experience was gathered on the cardiovascular benefits of exercise for the American Heart Association (5) and the federal government of the United States of America (6) to start publishing guidelines on exercise for the general public and for patients with cardiovascular disease. By the early 1990's, there was a gradual shift of focus from organ systems to molecular biology techniques (7), while the beneficial effects of physical training were becoming evident for many pathologies (see Fig 1). For instance, there were prospective data indicating that cardiorespiratory fitness is inversely related to mortality rates (8). In the mid-90's the American College of Sports Medicine, the Centers for Disease Control and Prevention (CDC) (9), and the World Health Organiza-

tion (W.H.O) with the International Federation of Sports Medicine (10) issued joint statements on "Physical Activity and Public Health" and "Exercise and Health", respectively. These were closely followed by the National Institutes of Health (NIH) Consensus (11), and by the report of the Surgeon General (12) on physical activity.

Given the potential impact on health care, one might expect that the scientific progress in exercise biology would have been translated into the medical education curriculum. We shall next examine this issue.

EXERCISE BIOLOGY TRAINING IN MEDICINE AND PUBLIC HEALTH

During the 19th century, the benefits of exercise were mostly intuitive as there was insufficient scientific data available to the clinician. Byford (1) said "It is seldom

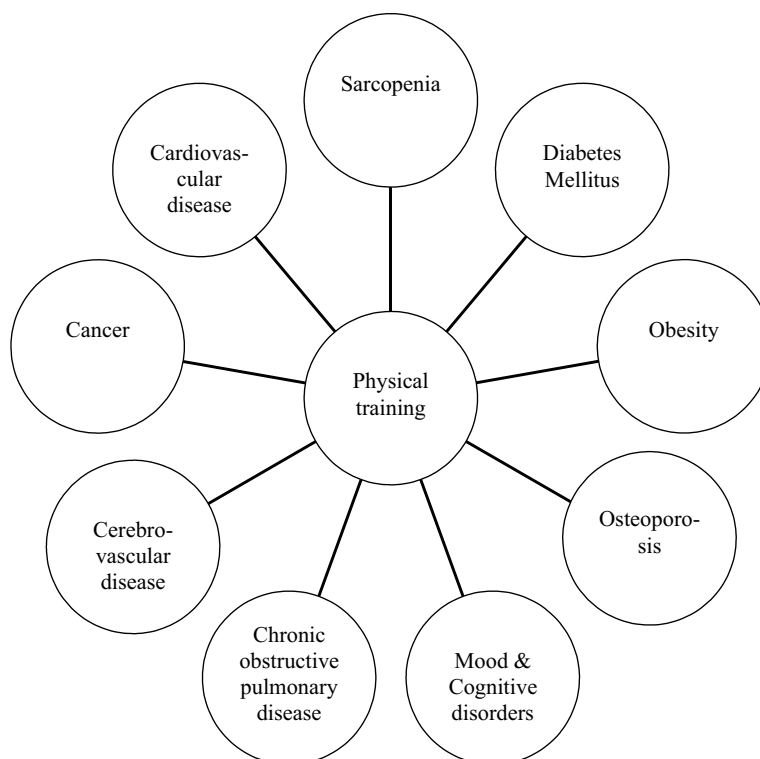


Fig. 1. Chronic diseases favorably modulated/treated by physical activity/physical training (for review see 6, 8-12, 33).

that any remedial means receives the importance due to it from the great body of the profession, unless its physiological *modus operandi* is rational and well understood. Although the importance of voluntary exercise has been recognized by centuries and prescribed to its most useful extent by many of the profession, its great practical advantages in a large number of diseases have not been appreciated to the full extent by all.”; calling on the profession for more research. By the end of the century there was concern that physicians were devoting years of study to pathological conditions and their relief, but very few hours to keeping a healthy body. Physical training was mostly associated with athletes, less to health. Brooks (13) stated that “Physical training has not yet acquired the dignity to be incorporated in the curriculum of medical study, but it is supposed to lie within the province of the gymnasium instructor or the professional athlete” (13). He wondered why little attention was being paid to the subject of physical training in medical schools.

Eggleton (14) stressed the importance of medical graduates to master “physiological therapeutics”, including medical gymnastics. It was stated “Medical gymnastics should be taught in medical schools by giving the student the physical exercise he needs in the form of instruction in specialized gymnastics, such as programs for patients with heart disease ... In all probability nothing will be done. Years will pass before a change will come, because the leaders of the medical profession are not conversant with these measures of treatment. If they know little or nothing about these measures, how can they be expected to provide adequately for them?” (14). Unfortunately, more recently, only 3% of physicians admitted to ever taking a course related to exercise prescription during their undergraduate, or their medical school education

(15). This is surprising since vast amounts of knowledge on exercise biology and its beneficial effects had been acquired in the 20th century, particularly in the latter half, with little, if any impact on medical education.

It has been over 150 years since Byford (1) called for research into the therapeutic effects of exercise. Much has been discovered since then. Leading professional medical organizations, national and international health organizations have endorsed the therapeutic effects of exercise. Exercise biology has kept up with other sciences and nowadays capitalizes on advanced technologies such as gene arrays, and plate readers. Today, the exercise biologist is at the forefront on the biological mechanisms by which exercise modulates gene expression in health, and in disease (16). Despite this, medical education leadership has remained reluctant to incorporate exercise biology to the core medical curriculum or to systematically implement it in graduate medical education.

VENEZUELAN EXERCISE BIOLOGY

Miguel González-Guerra reviewed (1891 to 1990's) the medical curriculum of the oldest medical school in the country, Universidad Central de Venezuela (UCV). His review indicated that exercise biology had not been part of medical education, at least in this leading medical institution. In 1978, the medical education commission of UCV approved sports medicine as an elective course (17), a step that has since been followed by other medical schools (i.e., Universidad de Carabobo). Although sports medicine has some overlap with exercise biology, its objective is athletic performance and the rehabilitation of injuries. Thus, medical students do not receive core training in exercise biology to preserve/restore health. In the 1930's, Victor Delfino made

reference, in the medical journal “*Gaceta Médica de Caracas*”, to European studies pointing at the scientific basis of “kinesiotherapy” and the numerous medical indications for “movement therapy” (18). In 1952, the Venezuelan National Institute for Sports founded the Central Medical Department in the capital, Caracas. Among its duties was research and education in human performance and sports medicine (19). This group would later collaborate on a research project on work physiology with a group at the UCV’s University Hospital (20). But, a review of the literature suggests that few Venezuelan laboratories have worked and published (internationally indexed peer-reviewed journals) in exercise biology.

The first documented Venezuelan studies of exercise biology were on work physiology, and date to the early 60’s, by the Institute of Work Medicine and Industrial Hygiene at University of Zulia. These series of studies were performed by Joachim Meyer-Delius and his associates on manual labor workers employed at a major foreign oil refinery, and on the National Guards Troops, both at Zulia state. They described “body efficiency”, using a cycle ergometer, at different workloads, under different heat and thermoneutral environmental conditions (21-25). Their findings indicate that working “body efficiency” was 25% lower, under heat, compared to thermoneutral environments (23), which was attenuated by physical training (24). In their reports, they pointed out that: 1) physiological studies, during “professional activities” (exercise), are the base for understanding preventive medicine (24), a concept that remains valid today; 2) the lack of physical exercise is a fundamental factor in the development of cardiovascular disease in the country. It was recommended to train more physicians in “work medicine”, advocate for sports in schools and companies, and create

“climatized gymnasiums” (23, 25). Have these recommendations been followed?

In 1962, the Section for Functional Cardiopulmonary Exploration, Division of Cardiovascular Diseases, of the Ministry of Health and Social Assistance, was founded at the Caracas University Hospital. This Section delivered services to patients referred to them from physicians from pneumonology, cardiology, anesthesiology, medicine, and other institutions such as the National Institute of Sports (19). This was the first group in the country to study work capacity, by directly measuring whole-body oxygen uptake (via pulmonary gas exchange), in a group of Venezuelans (i.e., sedentary subjects and athletes). Their findings indicate that, compared to normative European and North American data, the work capacity of Venezuelan athletes was similar, but sedentary Venezuelans were less fit (20). The authors hoped that their study would serve as a reference point for future studies in work capacity of cardiopulmonary rehabilitation patients, sports medicine and military medicine. Nearly 40 years have passed, it is unclear to what extent others have valued their initial work.

By the 1970’s a third group, headed by Sonia Hecker-Torres, of the Department of Physiological Sciences, Luis Razetti School of Medicine, UCV, began studies. Her laboratory worked on skeletal muscle physiology, including adaptations to physical training (26). Her group showed that physical training increases mitochondrial numbers and size (27), and enzymatic activity (26, 28) on feline gastrocnemius; a favorable adaptation for oxidative metabolism. In the early 1980’s she took a sabbatical with Bengt Saltin in Copenhagen, Denmark. Upon her return she used the Bergström’s needle muscle biopsy technique, and characterized the enzymatic activity, fiber type and capillarization of Venezuelan athletes (29-31). These studies (29-31) were helpful

in confirming and recommending possible changes in physical activity patterns consistent with the skeletal muscle fiber phenotype of the athlete. Torres and her associates have collaborated with the cardiology and neumonology service of the University Hospital to examine the effects of physical training on the skeletal muscle of patients with coronary disease (32) and chronic obstructive pulmonary disease (33); and the links between exercise performance and skeletal muscle characteristics in patients with Chagas's disease (34). Both studies (32, 33) trained the patients on cycle ergometers and treadmills at 70% to 80% of their peak oxygen uptake, 3 times a week for 6 weeks. Muscle biopsies and cardiopulmonary testing were performed before and after training. These studies show improvements in oxygen uptake, skeletal muscle histological and histochemical changes, similar to those observed in healthy subjects. The patients also reported an improvement on their health related quality of life. Taken together, these studies demonstrate that moderately intense exercise may serve as a valuable therapeutic tool in patients with coronary and, moderately, to severe chronic obstructive pulmonary disease.

In the 1980's a fourth group emerged, headed by Manuel Velasco and associates at the Clinical Pharmacology Unit, Vargas School of Medicine, UCV. Their work has been mostly patient-oriented research, conducting several studies examining cardiovascular response to exercise in hypertensive patients, sedentary subjects, and athletes. They have studied the modulating effect of dopaminergic agents (35, 36), clonidine and minoxidil (37, 38) and indoramin and propranolol (39). For instance, they have provided evidence that the blood pressure and heart rate response to exercise is modulated by the dopaminergic system and this effect in

turn, may be altered in hypertensive compared to normotensive individuals (35, 36).

The fifth and most recently established group operates out of the Department of Neumonology at the University Hospital, UCV. Their initial work was geared towards cardiopulmonary exercise testing in patients with chronic obstructive pulmonary disease (40). Since then, they have studied respiratory muscle recruitment and exercise performance in eucapnic and hypercapnic patients; reporting that exercise capacity and ventilatory muscle recruitment are similarly impaired in both types of patients (41). They have suggested that a stair climbing test is a simple way to determine maximum functional capacity, whereas the 6 Minute Walk test was more suitable to assess exercise tolerance (42). More recently, they have collaborated with Torres and associates to examine the relationship between exercise performance and skeletal muscle characteristics in patients with advanced Chagas's disease (34). They have also examined the effects of physical training on the skeletal muscle of patients with chronic obstructive pulmonary disease (33).

Many other groups have used exercise paradigms to examine various clinical questions. For instance, the effects of exercise on asthmatics (43), dysthymia (44), major depression (45), the cardiovascular response to amlodipine (46), the Valsalva maneuver (47), lipid, lipoproteins, lipases, and steroids (48). There have also been studies describing the effects of exercise on nitric oxide production (49), urinary cyclic guanosine monophosphate excretion (50), histamine levels (51) proteinuria (52), rhabdomyolysis (53), platelet function and hematology (54), and catalepsy (55). Most of the literature discussed to this point has been in adults and a few animal studies. There have been several investigators examining questions in pediatric exercise biology (56-58), which has been a field of interest

to the author (59-62). Their work (56-58) pertained to the use of exercise testing as a physiological model of stress to assess cardiovascular hyperreactivity, potential risks of premature hypertension and cardiovascular disease in adolescents (56-58). This line of work should be extended, as early detection of cardiovascular disease and prompt physical activity interventions should soon become a national health priority.

The author is aware of a small group of Venezuelans in exercise biology overseas, particularly in the United States of America. Rafael Reyes, received his doctorate from Louisiana State University in 2004, where he worked on the cardiovascular and hemodynamic response to resistance training in young and older individuals (63). Otto A. Sánchez, received his doctorate at University of Minnesota in 2004, where he worked on the effects of exercise training on single-fiber contractile properties of diabetic rats (64). Jazmir M. Hernández, received her doctorate from The Pennsylvania State University in 1999, where she used a rodent model to work on protein synthesis and glucose uptake in mixed gastrocnemius muscle after resistance exercise (65). The author of the present paper received his doctorate from The University of Tennessee in 1997 where he worked on the metabolic effects of low cortisol during prolonged exercise in adults (66). The scientific basis of "kinesiotherapy" and "movement therapy" date back at least to 1930. Exercise biology/physiology was initially studied in the 1960's as work physiology. There were warnings against the lack of exercise and its effects on cardiovascular disease, the understanding of the physiology of physical activity was postulated as the base for preventive medicine. Venezuelan scientists and clinicians have explored some areas of exercise biology, such as cardiopulmonary exercise testing, skeletal muscle adaptations to training and exercise cardiovascular phar-

macology, in patients, sedentary subjects and athletes. I find it deeply concerning that the international and national literature on exercise biology has had little noticeable effect on Venezuelan medical education. There is a need to orchestrate didactic and research programs in exercise biology to formally train physicians and non-physicians in the basic and clinical applications of exercise biology. In particular, a national initiative pooling together resources from the medical schools, schools of public health, physical education schools and the National Institute of Sports, is suggested.

TRANSLATION OF EXERCISE BIOLOGY: SUGGESTED TENTATIVE STEPS

Step 1. Identification of Training Programs

There is a master's degree in exercise physiology in the School of Physical Education at The Instituto Pedagógico, Caracas. In 2006 the national government inaugurated the Universidad del Deporte, in San Carlos, Cojedes State, where a 4 year physical education degree with a track specialization in "Physical activity and health" is available. The Universidad Rómulo Gallegos, in San Juan de Los Morros, Guárico State, has announced a Sports Medicine residency training program for 2006. The National Institute of Sports has inaugurated several national centers for applied science and medicine in sports (CENACADE) in several states (see www.ind.gov.ve). Taken together, these resources are meant to launch a robust national sports policy. If taken to its full length it will be a step forward as, previously, it was suggested that the nation had no clear national sports and physical fitness policy (67). These initiatives could benefit from joining forces with the existing research groups exploring exercise biology at

other national institutions. The scientific exchange would favor both sides and would facilitate a first step to develop programs for physical activity in health and disease. The next tentative step is education.

Step 2. Education

A) *Exercise Biology would be a valuable course for allied health care workers.* Physiotherapist, cardiopulmonary technologist, occupational therapists, and health information technologists would benefit from a course in exercise biology. B) *Exercise biologist should be trained and incorporated in the medical team.* The Ministry of Health, Ministry of Education and Sports, and the Ministry of Higher Education could facilitate a dialogue among medical, public health and nutrition schools along with the institutions identified in Step 1, to train the new doctoral-level health professional, the exercise biologist. C) *Exercise Biology should be incorporated into undergraduate and graduate medical education.* The course would be taught to medical students after most of the basic sciences (3rd year), at the clinical level (4th or 5th year), and to physicians in training (i.e., physical medicine, community medicine, family medicine).

Step 3. Service

The purpose of this step is to provide a service to the community, where: a) the individuals would be evaluated clinically by qualified staff trained in exercise biology; b) individualized exercise prescriptions would be generated; c) participants would be followed up at medical and sports facilities (appropriately equipped); and d) laboratory and clinical evaluations would be performed periodically. Who would be the target? Initially, the most in need; those with chronic diseases, the elderly, disabled, prisoners or those with drug addiction. Eventually, all adults at risk/with chronic disease (Fig. 1) would be targeted.

Step 4. Research

Although Step 1 calls for research collaboration as a link between developed and developing groups, Step 4 calls for organized research within the community program. The data collection generated from the hospital/community-based programs would provide valuable epidemiological data for the nation which could be useful to optimize service. Additionally, clinical/basic research protocols should be generated from this initiative with the end of generating publications for peer-reviewed, internationally indexed journals.

THE MISSION OF THE EXERCISE-BIOLOGIST

The graduates would be ready to join government initiatives geared to the maintenance of health and rehabilitation of disease (Fig. 1). To this end, the program would likely improve the quality of life, decrease intake of pharmaceuticals and eventually reduce financial health-care costs. The growth of this program would be, at least initially, dictated by demands of the National Government.

PERSPECTIVES

The dangers of the 20th and 21st century lifestyle have plagued our modern civilization, leading to physical decay and multiple chronic diseases. The scientific evidence of directed exercise training on health has been endorsed by the CDC, the Surgeon General, the NIH, and the WHO. Venezuelan clinicians and scientists have explored some areas in exercise biology such as cardiopulmonary exercise testing, skeletal muscle adaptations to training and exercise cardiovascular-pharmacology. Despite this, the medical education leadership has remained reluctant to incorporate exercise biology to the core medical curriculum

or to systematically implement it in graduate medical education. This phenomenon is not unique to Venezuela. This however, does not negate or weaken the priority to orchestrate a national initiative to formally train physicians and non-physicians in the basic and clinical applications of exercise biology.

Although the National Government has taken some steps regarding national sports policy "Deporte Para Todos" (Sports For All), most of its efforts are aimed to raise the quality of competitive athletes and less so to serve the health/medical physical activity needs of the adult and elderly population. Therefore, there is a need to bridge the gap between initiatives in exercise biology for "human performance" and the few existing in exercise biology for "health care". Pooling together resources from the medical schools, schools of public health, physical education schools and the National Institute of Sports would be an uphill endeavor without an orchestrated national leadership. The WHO called on governments around the world to consider the relationship between physical activity and health promotion. To make progress, it is vital that translation and dissemination occur. The crucial question is whether we have the will to take the necessary steps.

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