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THE BRAZILIAN DYNAMIC-COHORT STUDY "MOVING FOR HEALTH" AS A PROACTIVE MODEL OF EVOLUTIONARY/ BEHAVIORAL – MEDICINE TO NON-COMMUNICABLE DISEASES IN A COMMUNITY- BASED SUBJECTS

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Abstract: As an Evolutionary-Behavioral Medicine approach to care Non-Communicable Diseases(NCDs) patients, it is presented an allostasis pro-active model of lifestyle modification(LiSM), involving supervised-physical exercises and dietary counseling. For so it was used data(2005-2019) from the dynamic cohort study "Move for Health" supported by the public university, in free-attendance of the local urban community. Upon registration and filling out the ethical protocol, adults over 35-yr old were clinically selected for inclusion and thereafter, assessed for physical activity, fitness, dietary quality and food intake along with body composition and plasma biochemistry for diagnosing NCDs. Further on they are involved in one of the interventions with supervised physical exercises and counseled diet. The 1,218 subjects were 79% females, 51.2% over 60 yrs, old, 30% with family income<2minimum waive, over 90% diet-inadequacy and time-crescent physical inactivity(10.3% to 18.3%). Among NCDs, 39% were obese, 68.9% abdominal obesity, 52.1% MetS, 34.4% NAFLD, 16.1% T2D and 20.6% at CHD-risk>20%. Dietary inadequacy was distinctly influenced by schooling and income, whereas low-physical activity was common in those with either higher schooling or income, being the leisure activity the most discriminatory domain. The ranking of physical inactivity followed MetS(75.3%), Obes(62.8%), NAFLD(41.2%), T2D(37.8%) and CHD-high risk(18.3%). Graduates from a 2-yr LiSM referred themselves feeling healthier. The compliance varied from 12.4%(2yrs) to 52.3%(6mo.) and 65%(10wks). Six-mo. LiSM improved some dietary itens but not the whole diet(HEI). Similarly, the increased activity of leisure domain was compensated by the decreased domestic labor. A Six-mo. LiSM promoted 3.4% eutrophy, identically to 2-mo. LiSM plus dietary-fiber adequacy. Blood-hypertension normalization was LiSM-lasting and exercise-type dependent, whereas T2D was exercise-type only. MetS reduction was dependent on either exercise-type, protocol lasting or specific-dietary interventions. Hence, the proposed lifestyle-proactive approach would be an effective and money-saving alternative, for the drug-based reactive care of NCDs.
Keywords: Non-communicable chronic diseases, lifestyle modification effectiveness, public health economic savings.

RATIONALE

Healthier people earn and work more and might affect the national economy. Countries such as Brazil loose annually more than 20 million productive life-years due to non-communicable diseases(NCDs) (FORUM, 2008). NCDs are defined as a disease that is slow in its progress and long in its continuance (BURINI, Roberto Carlos, 2021a).

Measurements needed to manage the burden of NCDs are complex (FORUM, 2008) and, Brazil's national drug policy calls for distribution of essential drugs through his existing universal public health system(SUS). The expansion of pharmaceutical care and the free distribution of most NCD medications by SUS, play an important role in the Brazilian Government's effort to tackle those diseases (MINISTÉRIO DA SAÚDE. FUNDAÇÃO OSWALDO CRUZ, 2005).

Drug therapy used worldwide as measure in halting and reversing the NCDs epidemic, are expensive. In the first decade of this century(2002-2006), the prescription drug costs was the increasingly large component of overall health care costs of the Brazilian Ministry of Health, varying from 5.4% to 11% of total expenditure (BURINI, Roberto Carlos, 2021a). Overall, the increased expenditure with drugs varied from 16.36% in 2002 to 49.7% in 2003 and 45.85% in 2005, summing up 123.9%(2002-2006) (VIEIRA; MENDES, 2007).

The burden of NCDs in Brazil has demonstrated the onerous expansion of pharmaceutical care and the free distribution of most NCD's medications, as an ineffective action in controlling these diseases. Underlying why drug therapy has been largely unsuccessful in halting and reversing the NCDs epidemic would be the ineffectiveness of the treatment approach by homeostasis model (BURINI, Roberto Carlos, 2021b).

Both homeostasis and allostasis are endogenous systems responsible for maintaining the internal stability of an organism. Homeostasis describes mechanisms that hold constant a controlled variable by sensing its deviation from a "setpoint" and feeding back to correct the error. Based on this model physicians reason that when a parameter deviates from its setpoint value, some internal mechanism must be broken. Consequently, they design therapies to restore the "inappropriate" value to "normal". Hence, homeostasis treats low level targets, but constancy is not a fundamental condition for life. Yet the goal is not constancy, but coordinated variation to optimize performance at the least cost. This is the core idea of allostasis (BURINI, Roberto Carlos, 2021b). The allostasis model defines health as optimal predictive fluctuation. A system becomes unhealthy when, high demand predominates for long times, the allostasis model of physiological regulation, attributes NCDs diseases to sustained neural signals that arise from unsatisfactory social interactions (5).

Differently from treating low level targets by drugs (homeostatic model) and generating iatrogenesis, the allostasis model has a more rational goal of intervention with lifestyle modification of environmental factors (5). The allostasis model attributes the pathogenesis of obesity, metabolic syndrome and its components to prolonged adaptation to hypervigilance and hyposatisfaction to social interactions. Consequently, the allostasis model would redirect therapy, away from manipulating low-level mechanisms, toward improving higher levels in order to restore predictive fluctuation. Under this model the hallmark of health is the therapeutics of contemporary chronic diseases through changing lifestyle which seems more clinically effective than drugs (BURINI, Roberto Carlos, 2021b).

Currently, major diseases now rise in prevalence, such as obesity, type 2 diabetes, hypertension and metabolic syndrome, whose causes the homeostasis model cannot explain. Coincidentally, they all have evolutionary thriftiness involved in their contemporary origin (BURINI, Roberto Carlos, 2017; BURINI, Roberto Carlos *et al.*, 2016; BURINI, Roberto Carlos; TOREZAN; MCLELLAN, 2013; PORTERO MCLELLAN *et al.*, 2013).

Actual medicine ignores evolution, and instead focus upon proximate mechanical causes as modeled by mechanical physics, deriving from Galileo, Newton, and Descartes. As a result of assuming this model, medicine is mechanistic, materialistic, reductionist, linear-causal, and deterministic in its concepts. It seeks explanations for diseases, or their symptoms, signs, and cause in single, materialistic changes within the body wrought directly by infectious, toxic, or traumatic agents. Hence, current medicine is only beginning to explain the variability in disease susceptibility in individuals and populations (WEINER, 1998). The evolutionary thinking on medical issues can sometimes illuminate features quite unexpected by non-evolutionary approaches (STEARNS *et al.*, 2010).

Evolutionary Medicine can be defined as the application of the theory of evolution through natural selection to the understanding of human health problems. Evolutionary Medicine aims to explain diseases based

both on recent physiological causes, those most commonly addressed by medicine, and on more distant evolutionary causes, those responsible for the emergence and survival of useful and functional biological structures throughout the history of the planet (WELLS *et al.*, 2017).

Evolutionary Medicine rests on the assumption that functional biological characteristics are the result of evolutionary adaptive processes. Organisms are bundles of compromises shaped by natural selection and, humans and other primates have evolved particular morphological and biological traits. The evolution of these traits is viewed as product of interactions between intrinsic constraints and trade-offs—features inherited or acquired during development—and extrinsic factors in the environment that affect mortality risk and resource availability. Major constraints were famine and infection. Hence, life is the interplay between structure and energy and, the major functions involved in lifespan are maintenance, growth, reproduction, and defense, in which energy can be invested. For those, insulin resistance, sodium preservation and inflammation can be seen as thriftiness in situations such as famine, water privation and infection. For then, emerged the thrifty genotype that implies some degree of prosperity deriving from earlier frugality and a careful management of resources. Therefore, it is possible to analyze a great number of diseases in terms of adaptive vulnerabilities connected to our phylogenetic inheritance, such as human bodily inadequacies in relation to the modern environment (WAIZBORT; LUZ, 2017).

In fact, the mismatch of our ancestral thrifty genotype with the contemporary way of life would result in diseases such as obesity, T2D, essential hypertension, dyslipidemia and metabolic syndrome. Additionally, the disruptions of the equilibrium achieved in evolutionary conflicts of interest among relatives may be the basis of some mental diseases, particularly autism and schizophrenia. Thus, epigenetic modification of gene expression is one mechanism by which genetic susceptibility and environmental insults can lead to mostly of the contemporary NCDs (BURINI, Roberto Carlos, 2017; BURINI, Roberto Carlos *et al.*, 2016; BURINI, Roberto Carlos; OLIVEIRA; *et al.*, 2013; BURINI, Roberto Carlos; LEONARD, 2018; PORTERO MCLELLAN *et al.*, 2013).

Going beyond standard care, an understanding of each individual's ongoing life history could guide personalized decisions concerning the prevention, diagnosis, and treatment of disease (WELLS *et al.*, 2017). Thus, the growing worldwide burden of NCDs demands the implementation of effective population-based strategies. This is the basis of the Behavioral Medicine. Among its principles, dietary adequacy and physical activity as pillars of treatment. They could be a natural remedy for recovering part of the imbalance caused by modern life-styles, costless and without the side effects of many pharmacological treatments (BURINI, Roberto Carlos *et al.*, 2017, 2020).

As a model of Behavioral Medicine, a costless lifestyle modification programs have, alternatively to homeostatic model, proactively have promoted eutrophy and also, reduced blood hypertension, T2D and Metabolic Syndrome. This community-based ongoing epidemiological "Moving for Health Program"(MHP), has been conducted since 1991 and, is in very much tune with the ACSM's "Exercise is Medicine" initiative, and WHO proposal, The appliance of this Program and its effectiveness in reducing overweight (CASTANHO *et al.*, 2011), T2D (NAKAGAKI; KANO; BURINI, 2018), hypertension (BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013) and Metabolic

Syndrome (BURINI, Roberto Carlos; *et al.*, 2017) are outlined here, with an estimated economic impact on NCD care.

SAMPLE RECRUITMENT AND STUDY DESIGN

The Nutritional and Exercise Metabolism Center(CeMENutri) is a multiprofessional teaching and research center at the UNESP-Medical School, located in the city of Botucatu, a middle -size town, located in Sao Paulo, a southeast Brazilian state. The city economics is based on industry and agricultural and the city- hall along with federal welfare provide basics food supply and money transfer for the low-income population mainly family bearing children (PORTERO-MCLELLAN *et al.*, 2010).

From 1991 to 2019, CeMENutri offered professional-assisted programs of healthy-life promotion for the local schoolchildren and adults. Specifically for adults, over 35 years old, there is the MHP, a health care program intending to promote healthy lifestyle(LiSM) through adequate(counseled or prescribed) nutrition and appropriated(supervised) physical exercises (BURINI, Roberto Carlos; TOREZAN; MCLELLAN, 2013).

To join the MHP, adults from both genders come In to the CeMENutri and, in a free demand, upon registration and filling out the ethical protocol, they were submitted to clinical assessments allowing the inclusion criteria(first step). Once included, the second step of MHP was undertaken in a cross-sectional design involving lifestyle diagnosis of physical activity, fitness, dietary quality and food intake along with body composition and plasma biochemistry assessments for diagnosing non-communicable chronic diseases(NCDs). These assessments allowed the surveillance of the altered variables, in that community. The third step involved longitudinal approach with interventions with physical exercises and diet. Overall, it is considered a model of descriptive analytical prospective study involving a long lasting dynamic cohort("Moving for Health Program").

ASSESSMENTS

The baseline assessment included: clinical, anthropometric, dietary, physical activity(IPAQ), blood analysis, fitness(aerobic, strength and flexibility), and postural (NAKAGAKI; KANO; BURINI, 2019).

CLINICAL EVALUATION

After an initial physical activity- readiness questionnaire(PAR-Q), there was a physical examination to exclude severe cardiovascular diseases and other disable diseases for physical exercises (GOMES *et al.*, 2005).

PHYSICAL ACTIVITY LEVEL AND SOCIO-DEMOGRAPHIC VARIABLES

Physical activity level(PAL), socio-demographic(gender, age, marital status, family income and education) and health status were obtained by applying the International Physical Activity Questionnaire(IPAQ version 8 - long form) (CRAIG *et al.*, 2003)but diverse physical activity measures in use prevent international comparisons. The International Physical Activity Questionnaire (IPAQ. Marital status, schooling degree, family income and self-perception of healthiness were graded as previously described (MICHELIN, Edilaine; CORRENTE; BURINI, 2011). The recommended PAL was at least 150 minutes per week of moderate aerobic physical activity or 75 minutes of vigorous aerobic physical activity in the week (WORLD HEALTH ORGANIZATION (WHO, 2010).

PHYSICAL FITNESS

Physical fitness was evaluated through trunk flexibility(FLEX), upper limb strength

and cardiorespiratory tests(Nakagaki et al. 2019).The FLEX was evaluated by using the sit and reach test, following the normal values established by Johnson and Nelson (JOHNSON; NELSON, 1979). Muscle strength of upper limbs was determined by using the handgrip test with a hydraulic dynamometer, following the classification proposed by Baumgartner and Jackson (BAUMGARTNER; JACKSON, 1995).

Cardiorespiratory fitness was obtained in a treadmill test(Quinton, QMCTM90) following procedures established by the Balke protocol (WR, 1959). After obtaining the VO2 max. by the formula: VO2 max = 8.8+ (1.8* slope) +3.5 the cardiorespiratory fitness was classified following the values established by the American Heart Association (AMERICAN HEART ASSOCIATION, 1972).

FOOD INTAKE AND DIETARY QUALITY

A 24-hour recall was taken in three non-consecutive days, being one on weekend. An average of the 3 records was considered for each patient. The itens of the questionnaire are described elsewhere (PORTERO-MCLELLAN *et al.*, 2010). Data were processed by the NDSR(Nutrition data system for research, Minnesota University) program(Nutrition Data System 2010) and the Healthy Eating Index(HEI) modified for the Brazilian population was used to assess the quality of the diet (MOTA, João Felipe *et al.*, 2008)de ambos os sexos (54, desvio-padrão=10 anos.

ANTHROPOMETRY

Body weight and height measurements with subsequent calculation of body mass index(BMI = kg/m^2) was taken, along with measures of waist circumference(WC), Abdominal Sagittal Diameter(ASD) obtained as described previously (PIMENTEL *et al.*, 2011). Body fat composition was performed in the supine position by bioelectrical impedance(BIA)(Biodynamic®, model 450, USA). BMI was classified according to World Health Organization criteria ((WHO), 2000). For the BIA's %fat, it was adopted as normal reference the values between 15 to 25% for males and 20 to 35% for females (BRAY, 1992). For altered abdominal circumference, it was taken measures greater than 88 cm for women and 102 cm for men (GRUNDY *et al.*, 2005; NATIONAL CHOLESTEROL EDUCATION PROGRAM (NCEP) EXPERT PANEL ON DETECTION, EVALUATION, 2002).

BLOOD BIOCHEMISTRY

The antecubital-vein blood sampling was drawn after an overnight fasting. General chemists were performed by dry chemistry method(Vitros® 5600, Ortho Clinical Diagnostics, Johnson & Johnson Company, Raritan, NJ, USA). Serum insulin concentrations were measured by chemiluminescence method(Immulite 2000®, Siemens Healthcare Diagnostics, Marburg, Germany). The serum C-reactive protein(CRP) was measured by a high-sensitivity immune-nephelometric assay(Siemens Healthcare Diagnostics, Marburg, Germany).

Plasma malondialdehyde(MDA) was performed by high performance liquid chromatography with fluorimetric detection(HPLC; system LC10A®, Shimadzu, Japan). Analytical procedures were outlined elsewhere (MORETO *et al.*, 2015).

Homeostasis model assessment-insulin resistance(HOMA-IR) was calculated based on the following formula: HOMA-IR=[insulin (mU/mL)×Glucose (mg/dL)]/405. Insulin resistance was defined by HOMA-IR > 3.5 (VASQUES *et al.*, 2008).

NON-COMMUNICATED DISEASES

The anthropometric/biochemical

assessments allowed the diagnosis of overweight/obesity (CASTANHO *et al.*, 2011), abdominal obesity (BURINI, Roberto Carlos *et al.*, 2017) and insulin resistance/ T2D ((ADA), 2018; NAKAGAKI; KANO; BURINI, 2018).

Metabolic Syndrome was diagnosed when a minimum of 3 from its 5 components(WC, blood pressure, plasma glucose, TG and HDL-chol.) were altered (GRUNDY *et al.*, 2005; NATIONAL CHOLESTEROL EDUCATION PROGRAM (NCEP) EXPERT PANEL ON DETECTION, EVALUATION, 2002).

The algorithm based on BMI, waist circumference(WC), triglycerides(TG) and Gamma Glutamyl-transpeptidase(GGT) was used to develop the "fatty liver index"(FLI), by using the formula: FLI = [e0.953 × log(TG) + 0.139 × BMI + 0.718 × log(G-GT) + 0.053 × WC - 15.745/(1 + e0.953 × log(TG) + 0.139 × BMI + 0.718 × log(GGT) + 0.053 × WC - 15.745)] × 100. The algorithm varies between 0 and 100 with a FLI ≥ 60 ruling in the fatty liver (BEDOGNI *et al.*, 2006).

The algorithm based on age, BMI, presence of T2D, AST/ALT ratio, platelets counting and plasma albumin was used to develop the "NAFLD fibrosis score" denoting: Absence <-1.455; -1.455 to 0.676 tolerable; >0.676 presence of hepatic fibrosis (ANGULO *et al.*, 2007).

Plasma atherogenic index was calculated by formula involving the log of the ratio of triglycerides and HDL cholesterol levels in the plasma. The data were interpreted as: <0.11 low risk; 0.11-0.24 medium risk; >0.24 high risk for atherosclerosis and CHD (DOBIÁŠOVÁ *et al.*, 2011). For the Coronary Arterial Disease Risk it was used the algorithm of Framingham score assembling age, gender, tobacco use, total and HDL plasma cholesterol, presence of T2D, presence of hypertension(medicated or not). The risk is classified as: <10% low risk; 10%-20% medium risk; >20% high risk for CHD in the next 10 yrs (D'AGOSTINO *et al.*, 2008; WILSON *et al.*, 1998).

INTERVENTIONS

From the baseline assessments the participants were able to be assigned to interventions involving daily sessions of supervised exercises combined with counseled(or supervised) dietary interventions. The follow-up assessments occurred every 10 weeks (BURINI, Roberto *et al.*, 2012).

PHYSICAL EXERCISES

After a simulation in laboratory, the indirect calorimetry showed the two major exercise protocols (walking/jogging and localized muscular exercise) at the same duration(80min.), providing similar energy costs of both training sessions(walking 398+_86.7kcal X endurance 404±38.9kcal), without difference also between VO2max of both trainings. Among exercises, walking(15.6+_2.8mL/kg/min) was similar to endurance(13.2+_2.9mL/kg/min) and both, higher than flexibility(10.1±2.2mL/kg/min). None of exercises was classified as of vigorous intensity(>7METs). Each MET was calcutated as 2.7+_0.1mL/kg/min (COELHO-RAVAGNANI, Christianne de Faria *et al.*, 2013)0 ± 5,5 anos.

The supervised exercises involved aerobic activities(65-80% VO2max.) for 60-80min./ sessions. The exercise intensity was based on the subjective self- perception of effort(Borg scale) denoting moderate light/light heavy(Borg grade 11 to 13) (BORG, 1998).

The prescribed physical activity protocols (NAKAGAKI; KANO; BURINI, 2019) were hydrogymnastics in heated swimming pool (BURINI, RC, 2018); high Intensity Interval Training, 90% HRmax on treadmill (NAKAGAKI, 2017); resistance training in gymnasyum machines and free

weights(ORSATTI *et al.*, 2018); walking/ jogging aerobic training (BURINI, Roberto Carlos; TOREZAN; MCLELLAN, 2013) and mixed walking-gym (TALON *et al.*, 2015).

DIETARY

Dietary counseling was provided by dietitians in every two-weeks meetings with all participants to discuss the dietary modifications. The dietary intervention consisted of group discussion about benefits of a healthy diet to achieve an adequate body weight. The weekly group talkings encouraged participants to increase their daily intake of fruit and vegetables, whole grain cereals, legumes, low-fat dairy products, and lean meat, fish or poultry as recommended in the Food Guide for the Brazilian population (MINISTÉRIO DA SAÚDE, 2014). The follow-up assessments occur every 10-12 weeks (BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013).

For the schoolchildren(first to fifth grade students) the aim of the intervention was to improve their knowledge, attitudes and eating habits. The program included lectures and information about human body, the importance of energy and nutrients, consequences of higher energy intake and physical inactivity. It included also cooking classes, games and discussions about healthy/ unhealthy food and drink, composition of food and children's nutritional pyramid. The nutritionist presented nutrition material in an engaging manner to encourage children's participation. All parents were requested to complete questionnaire about child's eating behavior at baseline and after the 12-week program (MCLELLAN *et al.*, 2013).

Dietary interventions associated with physical exercises in the adult LiSM, were: energy restriction to 25kcal/kg BW (BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013), 30g fiber adequacy (BURINI, Roberto Carlos *et al.*, 2017; MCLELLAN *et al.*, 2015; RAMOS *et al.*, 2018)and W-3 LCFA supplementation (TALON *et al.*, 2015).

MAIN RESULTS

DEMOGRAPHIC AND SOCIOECONOMIC SURVEILLANCE

Results from 2005 to 2019 summing up data of 1,218 adults 55.0(35-85) years old, presented a socio-demographic profile of 51.2% over 60 yrs, 79% females, 68.6% married, 3.7% illiterate; 15.5% elementary grade; 59.2% high school, 21.6% university, presenting 30% income <2 minimum waive(MS)/40.2% 2-5 MS/ 32.8% 6-10 MS and 1.4% >10 MS.

DIETARY QUALITY SURVEILLANCE

It was found a food-intake profile of 1525±609 kcal/d, partitioned in 52% CHO; 17.9%prot. and 30.2% lipids. The ingested fat was 9% saturate, 9%MUFA and 7% PUFA (POLO *et al.*, 2019). The dietary quality(HEI) scored from 45 to 94 points (NASSUATO *et al.*, 2021). The inadequacy surveillance was 91.7% inadequate(HEI= 76.4±14.8 points), discriminated as 24.7% <70pts.(poor), 67.0% 70-100pts.(inadequate) along with 8.3% good quality(>100pts.) (POLO *et al.*, 2019). Concerning the dietary fiber intake, even in its higher quartile(25.7±8.8g/day), it was below the daily recommendation of 30g/ day, the found p50 was 14.1±2.0g/day. Also the ingested fruits, vegetables and whole grains were lower than RDA (MCLELLAN *et al.*, 2015). CHO/fiber ratio, illustrating single sugar intake, varied from 9.75(P25) to 18.97(P75) being P50=13.05 (BERNARDINO *et al.*, 2016). Another index of highly processed food was assessed by the ratio sodium/potassium. In a sample of 680 adults the baseline data showed the intake of 1154mg of sodium and 1936mg of potassium, with a ratio of 0.64 (SILVEIRA, 2020). This value is higher than the WHO recommendation of

<1.0 but similar to the <0.63 recommended ratio for healthy subjects. The recommended intake for potassium is at least 3150mg/day ((WHO), 2003). Also dairy(1.3±1.2 servings) and calcium intake(589±91.3 mg/day) were below the recommendation in 92.5% and 91.3% of individuals, respectively (POLO *et al.*, 2019).

Dietary inadequacy relationships

Educational level and income were important determinants of quality of diet. The higher income group had a higher HEI(82.9 x 78.0 pts) along with higher concentration of protein(% energy), lower total fat (% energy), and lower PUFA(% energy). The lower schooling and lower income groups had a poor quality diet characterized by higher caloric intake portioned as total fat and PUFA, reflecting a higher vegetable oil intake. MUFA and fiber intake were both similarly lower in both groups (PORTERO-MCLELLAN *et al.*, 2010).Lower income subjects receive monthly food supplies from their employers which consist basically of vegetable oil, salt, sugar, and refined carbohydrates. The oil they receive might be used to cook food and deep-fry vegetables or meat/poultry, which would contribute to their high percentage of fat in the diet. On the other side, the higher intake of protein and SFA among subjects with higher educational levels/ higher income, can be explained by their high consumption of meat(important source of protein and SFA). Protein rich foods(meat, poultry, and dairy products) are more expensive than carbohydrates and vegetable oil, and might be more consumed among subjects with higher income (PORTERO-MCLELLAN *et al.*, 2010). In this sense, the lower decile of dairy intake was associated with lower income, lower healthy score index, lower intake of total energy, lower intake of saturated fatty acids, and lower intake of calcium (POLO *et al.*, 2019).

According to their composition the found 3 pattern of diets(Traditional, Western and Healthy) showed the following associations: Traditional pattern with older subjects and ingested rice and beans, flours and pasta, whole dairy items, fresh juice, whole bread, fruits, non-starchy vegetables, popcorn and fish; Western pattern with higher educated individuals and with those who spent more money in food, "per capita" and the ingestion of pizza, small meals, instant pasta, sandwich cookies, plain cookies, sweets high in sugar and fats, mayonnaise and butter, sugary beverages and, the Healthy pattern with those who had the lowest income. All three dietary patterns were similar in their total energy intake, CHO, proteins, fats and MUFA. However, saturated fat and cholesterol intake were higher in Western pattern while Healthy pattern had higher PUFA (MARSOLA *et al.*, 2011).

Dietary interventions

In schoolchildren, a school-based 12-week intervention, including nutritional education and physical activity, showed results of 83.3% of change in their eating habits with an increased intake of fruits(64.3%), vegetables(61.9%) and water(52%). This "after school" program was conducted from 2005 to 2013, with schoolchildren engaged in 60 minutes/sessions, twice a week (MCLELLAN *et al.*, 2013).

In adults, a 6-mo. LiSM did not change the baseline energy intake of 2,008kcal/d for males and 1,607 kcal/d for females, maintaining also the energetic contribution of the components as 17.2%/51%/32% for protein/CHO/ Lipid in males and 17.4%/50.6%/32.3% in females (COELHO, 2020). However, another experiment with the same 6-mo. of LiSM resulted in reduction of energy intake from 1,603 to 1,506kcal/d(p=0.05). The baseline of HEI(85.6 X 85.3 points) was maintained

even with a light reduction of sugar servings and cholesterol intake(mg/d), along with slight increased servings of legumes and fibers(mg/d) and, a slight lower intake of cereal and fruits, as well. The best improvements in HEI was associated with those living alone and lesser in females and in those self feeling good state of health (MICHELIN, E *et al.*, 2021). In this same experiment, there was, after 6mo. of LiSM, an improvements on some dietary itens but not in the food quality(HEI) as a whole.

The recall averaging 3.4 yrs. later after stepping down the LiSM, registered an expressive mark of 56.6% continuing the activities of LiSM(compliance group) and 24.8% of the sample stopping completely the activities learned from the early- accomplished LiSM (MICHELIN, E *et al.*, 2021).

Effectiveness

The "take home lesson" from the 6-mo. LiSM was attested through a recall averaging 3.4 yrs. later after stepping down the LiSM. This registered 56.6% of subjects continuing the learned changed-life activities(compliance group) and 24.8% of the sample stopping completely the activities learned from the early- accomplished LiSM. The most referred dietary re-education maintained by the compliance group was the higher intake of fruits and legumes (56%) followed by reduced intake of fats, oils and fried foods(32%).

However, by their actual food-intake questionnaire, evaluated by nutritionists, the obtained figures showed the reality of 14.4% reduction in the good-quality diet by the increased inadequacies of fruits(25.5%), legumes(9.2%) and meat(13.7%) (MICHELIN, E *et al.*, 2021).

PHYSICAL INACTIVITY SURVEILLANCE

In our sample of 1,171 subjects, predominantly females, the median of physical activity was 641(450-570)min./week (COELHO, 2020) with 18.3% of the sample referring physical inactivity(< 150 min/wk). Roughly 10 years earlier, this rate was 10.3% (MICHELIN, E *et al.*, 2021) clearly showing an increasing in this century. Among users of the Family Health Strategy the rate of inactivity was 17% (MICHELIN, Edilaine; CORRENTE; BURINI, 2011). Recently, An analytical descriptive study showed 15.6% of the sample below 600METs/min/week (NASSUATO *et al.*, 2021).

Physical Inactivity Associated factors

The low physical activity levels were found in those with higher schooling and income (MICHELIN, Edilaine; CORRENTE; BURINI, 2011). Leisure physical activity was the most contrasting domain between subjects of higher and lower income/schooling. This probably was related to the fact that less educated and lower income subjects had low leisure physical activity during working days, differently from higher educated-higher income subjects. This opposite behavior occurred also on weekends, with the former looking for more sedentary behaviors (NAKAGAKI; MICHELIN; BURINI, 2017).

Intervention

The prevalence of low physical activity was reduced either by 24 or 10 weeks LiSM, both potentially by the increased activity of leisure domain (NAKAGAKI; MICHELIN; BURINI, 2017; NASSUATO *et al.*, 2021). However there was compensation in other domain, such as the decreasing of domestic labor. In a 10wk-LiSM there was a 2.12fold increase in physical activity (7.3h/wk X 15.5h/wk), but no difference was observed on the sitting time(sedentary behavior) either on week days or weekends (NAKAGAKI; MICHELIN; BURINI, 2017).

After 24wk-LiSM, the low physical activity decreased from 10.5%(baseline) to 1.3%, followed by a decrease of self- perception of bad health status from 26.1% to 9.8% (MICHELIN, E *et al.*, 2021).

Effectiveness

In our standard 24wk-LiSM there was a 7.2% decreasing of inadequate physical activity. In a recall 3.4yrs later stepping down the LiSM, 56.6% referred to be continuing with the physical exercises, while 24.8% fully stopped the learned physical activity, mainly by reducing the physical activity of the leisure domain. The non-compliance data was highly associated(OR 3.19) with the referred self-perception of bad-health status (MICHELIN, Edilaine; CORRENTE; BURINI, 2011).

INADEQUATE FITNESS SURVEILLANCE

The found fitness values for a sample of 1,171 subjects, predominantly females, averaged 24.3(23-26)cm for flexibility, 31.3(30.5-32.2)mL O2/kg/min. for aerobic performance and, 27% for the hand-grip strength (COELHO, 2020). The surveillance for insufficiency showed as bad trunk-flexibility from 51.8% and 68.8% (NASSUATO *et al.*, 2021) to 77.2% in users of the Family Health Strategy (MICHELIN, Edilaine; CORRENTE; BURINI, 2011). Likewise bad hand-grip strength varied from 48.4% in users of Family Health Strategy to 25% of general sample (MICHELIN, Edilaine; CORRENTE; BURINI, 2011).

Regarding the quartile distribution of the values, the top(very good) stage assembled 15.9% of the sample for flexibility, 11.2% for strength and 10.7% for VO2max.The quartile distribution of treadmill time were(male/female): 600s/394s(Q1), 601-752s/395-559s(Q2), 753-997s/560-706s(Q3) and >998s/>707s(Q4).Similarly, the distribution of VO2max. was 20.9±2.57mL/kg/min(Q1), 29.1±2.53mL/kg/min(Q2-Q3) and 37.8±598mL/kg/min(Q4) (MICHELIN, E *et al.*, 2021).

Associated factors

Among users of the Family Health Strategy, Individuals with elementary school and poor health perception showed, respectively, 3.2 and 2.7 times more likely to have bad hand grip strength (MICHELIN, Edilaine; CORRENTE; BURINI, 2011). Bad hand grip strength was associated with low muscle mass(MMI P10) persisting even after adjustments for gender, age, BMI, WC and IPAQ (MICHELIN, E *et al.*, 2021; TEIXEIRA, 2011). Men's data from Balke's treadmill test showed smooth decreasing of VO2max among decades of life(20s,30s,40s,50s and 60s) without difference from one decade to another for BMI and VO2max (RAVAGNANI *et al.*, 2006). A largely female sample (75.6%) showed Q1 VO2max predominantly male and smoker. Energy intake and HEI values were similar among all quartiles of VO2max showing commonly inadequate diets.

Interventions

Six-month LiSM increased 13% the treadmill time(608 X 687sec.) and 11.4% MET as well as VO2max (BURINI, Roberto *et al.*, 2012). This increased VO2max. was higher in males(9.6%) than in females(6.3%) (RAVAGNANI *et al.*, 2006). The detected bad flexibility at baseline(73.9%), was reduced by 19.3% after 6mo.-LiSM, with woman responding better than man (MICHELIN, E *et al.*, 2021). In the same period of LiSM, there was a 14.4% reduction of the low hand-grip strength. The improvements of all three fitness continued up to 24mo.-LiSM with a net increasing of lower-limb strength(28.2%), trunk-flexibility(20.4%) and VO2max(8.6%) (COELHO-RAVAGNANI,

CF *et al.*, 2011). The LiSM frequency of >3 days/week(>240min/wk) was better than <3 days/week(<240 min/wk) for increasing VO2max, upper arm strength and trunk flexibility, in both 3 and 6 months of LiSM (RAVAGNANI *et al.*, 2006). Ten-week training improved VO2max. similarly in all exercise protocols(Hydrogymnastics, HIIT, jogging/ walking, academy and mixed) while hand grip increased only in Academy-strength protocol (NAKAGAKI; KANO; BURINI, 2019).

Effectiveness

The gaining of 22% in lower-limb strength and of 7% VO2max., after 9mo.-LiSM was maintained during 1mo. detraining, differently of the gained flexibility(8%) that was lost with detraining (MICHELIN, Edilaine; COELHO; BURINI, 2008). From the gained fitness after 12-mo. LiSM, the 2mo.-detraining led to a significant loss in flexibility and hand-grip strength, and lesser in VO2max. (COELHO-RAVAGNANI, CF *et al.*, 2011). After 3.4 yrs. (average) of stepping down the 6mo.- LiSM, there was an expressive mark of 56.6% continuing the activities of LiSM and 40.2% with strength exercises (MICHELIN, Edilaine; CORRENTE; BURINI, 2011).

LiSM ENJOYMENT

An analytical descriptive study to check the degree of approval among participants finishing up a 10-wk LiSM, showed a major switching of physical activity from the domestic labor domain (at baseline) to the leisure domain (at the end of LiSM), without statistical differences over total energy expenditure. At the same period, the "Medical Outcomes Study 36-Item Short-Form Health Survey" (SF-36) indicated quality of life showing improvements in six of its 8 domains. Thus, although not changing the energy expenditure, the 10-wk LiSM promoted accentuated improvements in quality of life (NASSUATO *et al.*, 2021). Similarly, the full acceptance of our LiSM was reported by subjects that concluded the 6mo. LiSM (MICHELIN, E *et al.*, 2021). Early on, an open non-structured interview conducted by a guiding question answered by 2-year participants of the LiSM(74% females), indicated that 96% of respondents mentioned the changes related to the physical domain; 67% reported the psychological changes, and 83% mentioned changes in the social domain. Males and females showed a similar behavior of feeling in better health, more energetic-life and weight reduction or maintenance in the physical domain, the feeling of joy and satisfaction for the psychological domain and increased number of friends concerned the social domain (COELHO-RAVAGNANI, CF *et al.*, 2011).

LiSM COMPLIANCE

Once fulfilled the enrollment-eligibility the subjects began the LiSM and are free to stay in as long they accomplish the rules of attending 2-5 physical exercises sessions a week, dietary meetings and the 10-12wks assessments. The compliance of the enrolled patients was 65% at the first 10 weeks, 52.3% at the first semester, 47% at the first year, 12.4% at the second year and 6.3% at the 3rd year(Figure 1).

In a recall 3.4 years latter discontinuing the 6mo.-LiSM, all responders approved the LiSM that they had been on and, 53.6% had assumed to be still compliant with the learned habit of regular physical activity but, 7.8% responded not to be involved in any leisure physical activity at all (MICHELIN, E *et al.*, 2021).

URVEILLANCE OF NON-COMMUNICABLE DISEASES

According to their BMI, 18.6% of the sample was eutrophic, 42.5% overweight and 39.0% obese. Altered WC(GRUNDY *et al.*, 2005;

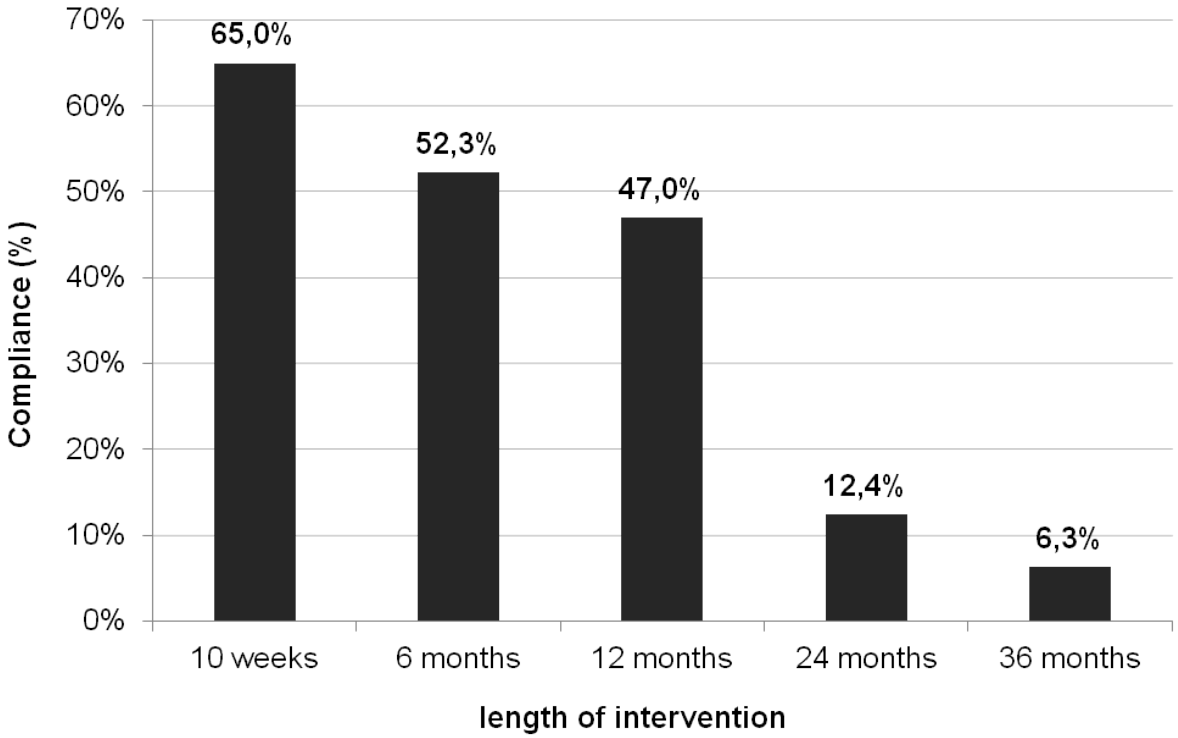

Figure 1. Compliance of the lifestyle modification program "Move For Health" (COELHO-RAVAGNANI, CF *et al.*, 2011).

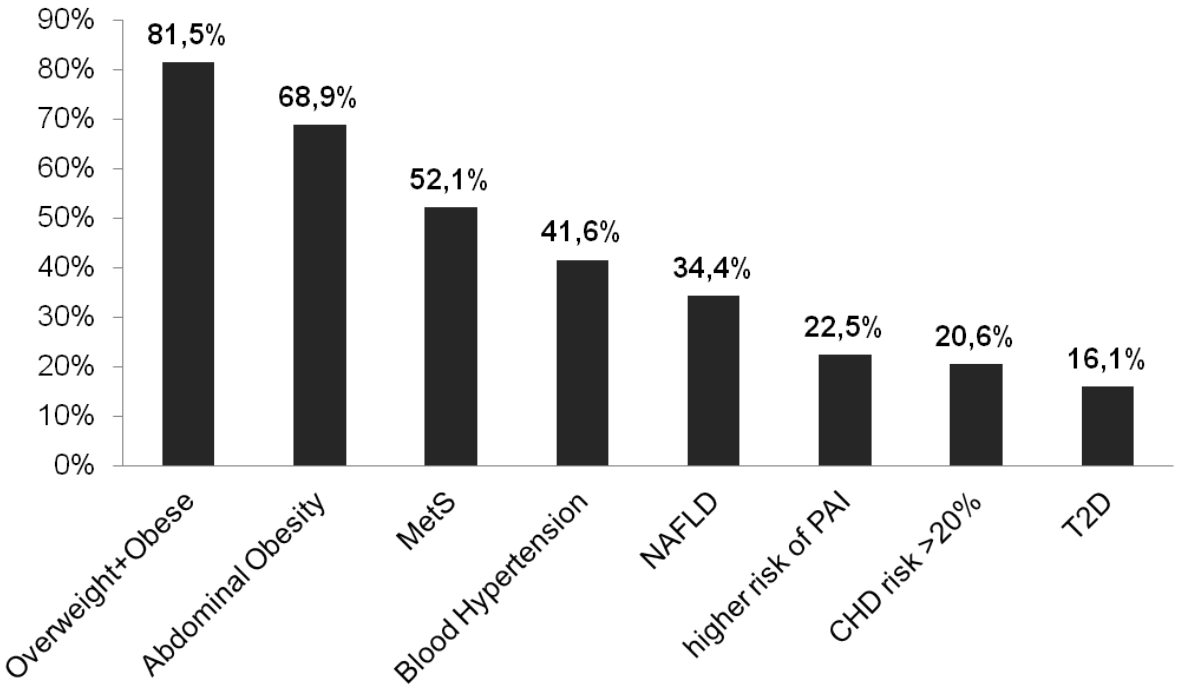

Figure 2. Prevalence of metabolic abnormalities in the studied sample.

NATIONAL CHOLESTEROL EDUCATION PROGRAM (NCEP) EXPERT PANEL ON DETECTION, EVALUATION, 2002) was detected in 68.9% of individuals; 52.1% MetS and 34.4% NAFLD; 22.5% at higher risk of PAI, 41.6%% blood hypertension, 20.6% with CHD risk >20% and, 16.1% T2D(Figure 2).

From the 2004-2013 data, 73.8% were diagnosed as having at least one of the following parameters: blood hypertension(40.2%), hypercholesterolemia(55.1%), low HDL-cholesterol(48.9%), hypertriglyceridemia(42.3%) and hyperglycemia(18.7%). Among these patients, 79.5% were medicated and 20.5% were medicated-non controlled patients. The medicated-non controlled hypertensives were 28.8%, hyperglycemic 6.83% and dyslipidemic 5.57% (BURINI, Franz H P *et al.*, 2015). Self-perception of health status gave 26.1% as in bad status (MICHELIN, E *et al.*, 2021).

Environmental Behavior Associated With Non-Communicable Diseases

The socio-demographic and behavioral(dietary and physical inactivity) factors for NCDs are depicted in Table 1. Being older influenced high-blood pressure and MetS, whereas lower schoolarity and lower family-income were linked to overweight/obesity, high blood pressure and MetS.

The poor quality diet(HEI <70 pts) was higher than 50% in situations of MetS(69%), T2D(65.1%) and obesity(52.3%). Higher fat intake was associated with overweight/obesity, insulin resistance/T2D and high blood pressure, while specifically higher oil intake was linked to overweight/obesity and higher saturated fats was more common in MetS(Table 1).

Lower intake of fruit and legumes was common characteristics of overweight/obesity, insulin resistance/T2D and MetS. Lower fiber intake and higher refined foods characterized the insulin resistance/T2D, whereas higher intake of CHO, processed foods and sodium were the consumption profile of high blood pressure(Table 1).

For the insufficient physical activity (IPAQ<150min/wk), the sequence was MetS(75.3%), Obes(62.8%), NAFLD(41.2%), T2D(37.8%) and CHD high risk(18.3%). For aerobic unfitness (P25 VO2max.), the sequence was MetS (80.6%), T2D(76.9%), NAFLD(72.6%), CHD(69.4%) and Obes. (45.1%)(Table 1).

Inteventions

The reductions of NCDs by LiSM are depicted in Table 2. The effects including both supervised(aerobic) physical exercises and nutritional counseling conducted in adults, decreased obesity rates by 1% in 10 weeks, 4.3% after 6 months of intervention, 7.7% after 12 months, and 7.8% after 24 months. The responses occurred similarly in men and women and, for the same length of LiSM, aerobic exercises were more efficient than combined or strength-only exercises in promoting weight loss, reaching better results in 12 months intervention (COELHO-RAVAGNANI, CF *et al.*, 2011); 3.4% of overweight subjects became eutrophic after 6 months of LiSM with aerobic exercises (CASTANHO *et al.*, 2011). Identical rate was achieved in short 2wk of LiSM by combining exercises dietary fiber adequacy(25 g/day) (MECCA *et al.*, 2012).

Body fat and waist circumference decreased faster by a 20 week-intervention protocol of physical exercise plus oral supplementation of omega-3 polyunsaturated fatty acid (TALON *et al.*, 2015) and, even faster, by 10-wk protocol of exercise plus dietary fiber adequacy (MECCA *et al.*, 2012). The effects of a LiSM including both supervised (aerobic) physical exercises and nutritional counseling conducted in adults decreased T2D rates

	Risk Factors			
Pathology	Demographic Socioeconomic	Dietary intake	Physical Activity/fitness	References
Obesity/overweight	lower schoolarity	higher fats	lower IPAQ	22
	lower income	higher oil	lower flexibility	
		lower dairy lower fruits lower legumes	lower aerobic	
Insulin resistance/T2D		higher fat	lower aerobic	71, 73
		higher refined foods lower fibers lower fruits		
Higher Blood Pressure	older	higher fats	lower aerobic	19, 53
	lower schoolarity	higher carbohydrate		
	lower income	higher sodium		
		higher processed foods lower diet quality lower dairy		
		higher saturated fats lower fruits		
		lower diet variety		
Metabolic Syndrome	older	higher saturated fats	lower aerobic	21
	lower schoolarity	lower fruits		
	lower income	lower diet variety		

Table 1. Found risk for non-communicable chronic diseases.

	Length of intervention				
	10 weeks	20 weeks	24 weeks	1 year	2 years
Obesity	–1%		–4,3%	–7,7%	–7,8%
Blood Hypertension	–16%	–21,3%		–31,6%	
Type 2 Diabetes	–64,8%	–68%	–60,5%		
Metabolic Syndrome	–16,9%		–24,2%		

Table 2. Effectiveness of the protocol duration on the non-communicable chronic diseases reductions

by 64.8% in 10 weeks, 68% after 20 weeks, and 60.5% after 24mo.-LiSM(Table 2). The blood pressure normalization with LiSM varied from 16% at 10wk-LiSM to 21.3% at 20wk and, 31.6% after 12mo.-LiSM(Table 2) in a clearly time-dependent response, similar to obesity(Table 2) (BURINI, Roberto Carlos *et al.*, 2017; BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013).

The effects of a LiSM including both supervised(aerobic) physical exercises and nutritional counseling conducted in adults decreased MetS rates by 16.9% in 10 weeks and 24.2% after 24wk-LiSM(Table 2) (BURINI, Roberto Carlos; *et al.*, 2017).

For the same length of 10 weeks, the 4 used exercise-protocols showed different effects on NCDs(Table 3). The lifestyle change protocol with dietary counseling and supervised walking-jogging exercises, reduced T2D by four exercise protocols such as high intensity interval training(HIIT:75%), Strength-Academy(Acad:71.3%), Mixed aerobic-Academy(Mix:78.6%) and Hydro-gymnastic(Hydr: 34.3%). After the 10-wk intervention, the most effective protocol was HIIT either in reducing T2D or promoting impaired fasting-plasma glucose(IFG) normalization. Acad. and Mix. followed closely HIIT for T2D reduction but with lower effectiveness on IFG normalization. Hydr. showed the lowest effectiveness either for T2D reduction or to IFG normalization (NAKAGAKI; KANO; BURINI, 2018).

The responsiveness of hypertensive subjects to different types of physical exercises in a 10wk-LiSM showed an average of 16% reduction from baseline, Both, SBP and DBP, were reduced by Hydr. but only SBP by the Mix. protocol. After adjustments hypertension was more reduced by Acad., Mix. and Hydr. (BURINI, Roberto *et al.*, 2017).

The effectiveness of four different physical -exercise protocols in a 10 weeks intervention on Metabolic Syndrome(MetS) and its components, was investigated in adults clinically selected for our LiSM. All groups received the same basic LiSM dietary counseling given by nutritionists. In general, there was a 16.9% reduction in MetS, from 25.4%(Hydr.) to 12.7%(Mix.), having HIIT(21.5%) and Gym.(16.2%), in between. Thus, whatever the type of exercise protocol, the LiSM program seems an effective strategy to reduce MetS, at the same length of intervention (NAKAGAKI; KANO; BURINI, 2019).

Cost-Effectiveness

Regarding the effectiveness of LiSM, considering the estimated extra cost of overweight/obese Brazilians as being US$0.50/subject(US$36 mi/72573.235 subjects) the economy of this LiSM for the public health(3.4% eutrophy promotion) would be of US$ 1.23 mi in either 6 months of LiSM with exercises and dietary counseling or in 10wk of LiSM associated with dietary fiber

	Hydro	HIIT	Academy	Mixed(Aerobic+Academy)	References
Blood Hypertension	–25,3%	–2,3%	–18%	–16,5%	45
Type 2 Diabetes	–34,3%	–75%	–71,3%	–78,6%	19
Metabolic Syndrome	–25,4%	–21,5%	–16,2%	–12,7%	23

Table 3. Effectiveness of the physical exercise type on the non-communicable chronic diseases in a 10-week protocols.

intervention. This economy would be enough to replicate this LiSM in all existing Brazilian cities, with 80 patients/each for more than 100 years to come (CASTANHO *et al.*, 2011).

In 2011, the Brazilian- outpatient costs of T2D was estimated by the ESCUDI study (BAHIA *et al.*, 2011), as US$ 2,108 per patient/year. This consisted mostly from direct costs(63.3%). According to another study, the individual cost would be US$ 12.66, totalizing a national expenditure of US$ 195 mi. a year (MALERBI; FRANCO, 1992). In our community-based dynamic cohort, the lifestyle change protocols have reduced T2D significantly after either 24 or 10 weeks of mixed(walking+strength) exercises (BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013; MOTA, J; MORETO; BURINI; *et al.*, 2011). On the economic basis, our LISM intervention(with 60.5% effectiveness) if applied to the 11.25 million of Brazilian(15.4% of total) suffering from T2D and IFG (BERTOLDI *et al.*, 2012; BURINI, Franz H P *et al.*, 2015; BURINI, Roberto Carlos *et al.*, 2014) , it would allow a Brazilian Public Health saving of US$ 16.49 mi. from expending less oral hypoglycemic drugs (MOTA, J; MORETO; MEDINA; *et al.*, 2011). Considering the given annual cost of diabetes as US$ 3.9 billion and having 5% of this as the oral agent costs, this LISM, if applied nationwide would save yearly US$ 195 mi. Overall by applying the demonstrated effectiveness of 14.8%, to the whole universe of 15.4% Brazilian T2D and IFG, one would save US$8.2 to 97.5 million/6 mo. to the Public Health System by enrolling these patients in our kind of LISM program (MOTA, J; MORETO; MEDINA; *et al.*, 2011).

In Brazil, the cost of medication spent for each diagnosed hypertensive subject(BH) varies for either one(US$ 87.10), two(US$ 159.00) or three(US$ 194.00) drugs, averaging US$ 39.50/month (MOREIRA *et al.*, 2009). The effectiveness of our 10wk-LiSM in normalizing SBP hypertension was 17.8%, by discounting 9.3% of the normotensives that became hypertensive there was a net effectiveness of our LiSM of 8.5%, for normalizing SBP. Once applied nationwide this LiSM would save BH medication for 3.1 million of hypertensive, at economic costs of US$ 1.47 billion/year (BURINI, RC, 2018). In a 8-month long LiSM involving hypertensive non-medicated men, the effectiveness of 38%, led to an estimated cost savings of US$14.2 billion a year (BURINI, Roberto Carlos; SIMONETTI; *et al.*, 2013). The professional cost(with student fellowships) of our LiSM program was estimated as US$ 900/mo. without considering indirect costs of laboratory tests and physical plant(gymnasium) use and conservation. Hence, by saving the current drug-expending costs with BH, the alternative treatment given by the presented LiSM could be set up in mostly of the 5,560 Brazilian cities, mainly those provided by public medical schools either by public or private health systems (BURINI, Roberto *et al.*, 2017).Thus, exercise training is a time- and type-dependent tool, feasible, costless and scientific-based rheostatic- allostatic alternative for the current "sick-care" drug-dependent homeostatic approach to BH med care (BURINI, RC, 2018).

FINAL REMARKS

The aim of public health is to prevent disease, promote health, and prolong life in human populations through the organized efforts of society. Physicians and public health professionals deal with phenotypes, but bodies are shaped in small increments to maximize reproduction or genetic fitness, not health. Therefore bodies are vulnerable to disease, and remarkably resilient. Consequently, public health interventions might not always achieve exactly what they intended. Evolutionary Medicine aims to explain diseases based

both on recent physiological causes, those most commonly addressed by medicine, and on more distant evolutionary causes, those responsible for the emergence and survival of useful and functional biological structures throughout the history of the planet. Hence, going beyond standard care, an understanding of each individual's ongoing life history could guide personalized decisions concerning the prevention, diagnosis, and treatment of disease. Considering the growing worldwide burden of NCDs, the implementation of other than reactive-homeostasis approach in population-based strategies for NCDs care, open up spaces for the Behavioral Medicine, in which dietary adequacy and physical activity are pillars of treatment. As though, the ongoing epidemiological experience("Moving for Health Program"), presented here, is a model of Behavioral Medicine based on costless lifestyle -modification procedure, alternatively to the current onerous- homeostatic model adopted by the Public Service. Though, the proposal could be a natural remedy for recovering part of the imbalance caused by modern life-styles, costless and without the side effects of many pharmacological treatments.

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