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TERAPIJSKI ASPEKTI INDIVIDUALNO DOZIRANE FIZIČKE AKTIVNOSTI

Sažetak: Insulinska rezistencija (IR) sa posledičnim hiperinsulinizmom je u osnovi nastanka razvojnog procesa od gojaznosti ka nastanku insulin nezavisnog dijabetesa (NIDDM). Ovom procesu doprinosi i smanjena fizička aktivnost koja se manifestuje smanjenom fizičkom sposobnošću. Pod uticajem redovne individualno dozirane fizičke aktivnosti aerobnog karaktera može se povećati biološka efikasnost insulina i uticati na proces nastanka rane i evolutivne arterioskleroze. Iznalaženje što efikasnijeg programa fizičke aktivnosti u sprečavanju ovih procesa cilj je njihove primene u preventivne i terapijske svrhe.

Ključne reči: gojaznost, insulinska rezistencija, insulin nezavisni dijabetes, fizička aktivnost, program fizičke aktivnosti

Abstract: Insulin resistance (IR) with resultant hyperinsulinism is basically the origin of the development process from obesity to insulin-independent diabetes mellitus (NIDDM). This process contributes to a reduced physical activity that is manifested in a reduced physical ability. Under the influence of a regular individually measured physical activity of aerobic character, it is possible to increase biological efficiency of insulin and affect the process of early and evolutive atherosclerosis. Finding a more effective program of physical activity for preventing these processes is the goal of their preventive and therapeutic application.

Key words: obesity, insulin resistance, insulin-independent diabetes mellitus, physical activity, physical activity program

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Uvod

Prvi pisani podaci o uticaju fizičke aktivnosti na zdravlje potiču od Kung Fua iz drevne Kine i stari su oko 500 godina. Tek krajem prošlog veka objavljena su prva naučna istraživanja o uticaju fizičke aktivnosti na zdravlje. U tom cilju formirani su kriterijumi za doziranje fizičke aktivnosti zdravstvene namene (1). Sedatarni način života zastupljen je u zapadnim zemljama sa tendencijom širenja u zemljama u razvoju. Uočen je porast hroničnih degenerativnih oboljenja, kao što su kardiovaskularna, metabolička, endokrinološka, oboljenja lokomotornog sistema čija se etiologija može dovesti u vezu sa smanjenom fizičkom aktivnošću (1,2). Po definiciji, hipokinezija je nedovoljan nivo aktivnog kretanja. Osnovna karakteristika hipokinezije je takav nivo telesne aktivnosti koji je hronično ispod praga nadražaja koji omogućava održavanje funkcionalnog kapaciteta najvažnijih organskih sistema (3).

Fiziološke karakteristike aerobne sposobnosti

Fizička radna sposobnost se u praksi najčešće identifikuje sa aerobnom sposobnošću, odnosno sa maksimalnom potrošnjom kiseonika (V_{O_2}) max koja je izražena u l/min, ml/kg/min ili Met-ima. Najvažniji simptom hipokinezije je smanjenje aerobne sposobnosti što je praćeno smanjenjem fizioloških i morfoloških procesa u organizmu, posebno onih koji koriste kiseonik kao energent pri radu submaksimalnog intenziteta (4,5). Pod uticajem smanjene fizičke aktivnosti nastaju morfološke i funkcionalne promene u organizmu. Dolazi do smanjenja mišićne mase, tonusa i snage, smanjenja gustine mišićnih kapilara i broja mitohondrija, kao i oksidativnih enzima. Smanjenjem mase miokarda nastaje smanjenje udarnog volumena srca sa povećanjem srčane frekvencije. Nastaje i smanjenje koncentracije lipoproteinske lipaze uz povećanje ukupnog i LDL holesterola, triglicerida, smanjenje HDL holesterola. Smanjenje broja, senzitivnosti i efikasnosti insulinskih receptora dovodi do pojave hiperinsulinemije i hiperglikemije (2,5,6). Novija istraživanja ukazuju na povezanost snižene fizičke aktivnosti i povećane učestalosti karcinoma pluća, kolona, jajnika, dojki i prostate (7,8,9,10).

Može se zaključiti da je uticaj sniženog nivoa aerobne sposobnosti nezavisan faktor rizika za nastanak kardiovaskularnih, metaboličkih i nekih malignih oboljenja.

Za suzbijanje nepovoljnih zdravstvenih efekata fizičke neaktivnosti neophodno je dostizanje i održavanje prosečnog nivoa fizičke sposobnosti. U svim životnim dobima neophodna je određena fizička aktivnost za održavanje „fiziološkog fitnesa“, koji podrazumeva optimalno odvijanje metabolizma masti, ugljenih hidrata, održavanje telesne mase i odbrambenih sposobnosti organizma (11). Ljudi funkcionišu, izgledaju i osećaju se bolje kada vode aktivan život (WHO, 1998) (9).

Principi programiranja fizičke aktivnosti zdravstvene namene

Zdravstveni efekti fizičke aktivnosti mogu se očekivati samo onda kada su isključene kontraindikacije za njenu primenu i kada je fizička aktivnost pravilno dozirana (12). Nedovoljna fizička aktivnost neće izazvati adaptacione odgovore neophodne da bi se ostvarili odgovarajući zdravstveni efekti, dok predozirana fizička aktivnost izaziva različite oblike oštećenja zdravlja. Osnovni cilj programa fizičke aktivnosti zdravstvene namene jeste povećanje aerobne sposobnosti ($\dot{V}O_2$)_{max}. Program individualno dozirane fizičke aktivnosti napravljen je tako da je prilagođen biološkim karakteristikama osobe, odnosno nivou aerobne sposobnosti i zdravstvenog stanja učesnika programa. To je program prilagođavanja i odnosi se na učestalost, intenzitet i trajanje fizičke aktivnosti uz primenu opštih preporuka o obliku fizičke aktivnosti.

Američki koledž za sportsku medicinu (ACSM) postavio je globalne principe modeliranja fizičke aktivnosti koji se odnose na intenzitet, učestalost i trajanje programa fizičke aktivnosti aerobnog karaktera (13):

1. Učestalost vežbanja: 3 – 5 dana u nedelji.
2. Intenzitet vežbanja: 60–90% maksimalne frekvencije srčanog rada (HR_{max})² ili 50–85% maksimalne potrošnje kiseonika ($\dot{V}O_2$)_{max} ili maksimalne rezerve frekvencije srčanog rada (HR_{max} reserve). Maksimalna rezerva srčanog rada izračunava se iz razlike između maksimalne frekvencije srčanog rada i frekvencije srčanog rada u mirovanju (HR_{min})³ (Karvonen, 1957).
3. Trajanje vežbanja: 20–60 min kontinuirane aerobne fizičke aktivnosti. Trajanje zavisi od intenziteta aktivnosti; tako da aktivnost nižeg intenziteta treba sprovesti u dužem trajanju.
4. Oblik aktivnosti: preporučuje se fizička aktivnost koja angažuje velike mišićne grupe koje se mogu odvijati kontinuirano i koje su aerobne po prirodi, kao što su hodanje, planinarenje, trčanje, džoging, vožnja bicikla, ples, penjanje stepenicama, plivanje, klizanje i igre tipa izdržljivosti.

U praksi se za doziranje intenziteta opterećenja, preko maksimalnog prirasta pulsa (koji se smatra identičnim doziranju preko ($\dot{V}O_2$)_{max}, koristi formula Karvonena: $TP = k(fC_{max} - fC_{min}) + fC_{min}$, u kojoj su TP = trenažni puls, fC_{max} = maksimalna frekvencija srčanog rada (izračunava se preko formule: $220 - \text{godine starosti}$), fC_{min} = vrednost jutarnjeg pulsa u postelji neposredno posle buđenja. Vrednost koeficijenta k je od 0,5 do 0,85% kada se trenažno opterećenje dozira u rasponu od 50% ili 85% od maksimalnog prirasta pulsa.

Za parametre fC_{min} , fC_{max} , MPP i ($\dot{V}O_2$)_{max} kod svakog ispitanika pravi se individualni „dozimetar“ za intenzitet opterećenja i to na sledeći način:

² $HR_{max} = 220 - \text{godine starosti}$.

³ HR_{min} – jutarnji puls izmeren u krevetu neposredno posle buđenja.

- a. Preko formule Karvonena određuju su vrednosti trenažnog pulsa koji odgovara intenzitetu rada u rasponu od 40% do 80% MPP. Tokom sesija fizičke aktivnosti primenjuju se intenziteti opterećenja na tredmilu, koji odgovaraju intenzitetima rada od 45 do 55% u fazi zagrevanja i hlađenja, a 55 do 70% u fazi sesije vežbanja.
- b. S obzirom na to da intenziteti rada izraženi u %MPP odgovaraju $\%(VO_2)_{max}$, za svaku vrednost trenažnog pulsa u rasponu 40 – 80% MPP obračunava se energetska cena u $(VO_2)_{max}$ i izražava se u kcal ($1 / (VO_2) = 5$ kcal.)
- c. Na osnovu analize memorijskih pulseva u svakoj sesiji fizičke aktivnosti, intenzitet izvršenog rada izražen je preko prosečne vrednosti TP i %MPP ($\%(VO_2)_{max}$), a energetske cenu sesija preko ukupne kalorijske potrošnje.

Inicijalni nivo fizičke sposobnosti je važan faktor za doziranje intenziteta vežbanja. Osobe sa niskim nivoom fizičke sposobnosti mogu dostići značajne trenažne efekte čak i uz trenažni puls na nivou 40 – 50% HR max rezerve. Osobe sa višim nivoom aerobne sposobnosti zahtevaju trenažne stimuluse većeg intenziteta. Niži do umeren intenzitet fizičke aktivnosti dužeg trajanja, posebno se preporučuje kod odraslih osoba, nesportista, zbog činjenice da se ovakvi naponi lakše podnose i zbog mogućih rizika koje izaziva visok intenzitet fizičkog napora (13).

Množenjem prosečnog intenziteta napora u kcal/min i njegovog trajanja u min, dobija se ukupna energetska cena izvršenog rada u okviru svake sesije vežbanja. Smatra se da energetske zahteve pojedinih sesija vežbanja u okviru programa fizičke aktivnosti za povećanje aerobne sposobnosti ne bi trebalo da budu niži od 150kcal (13,14).

Modelovanje programa fizičke aktivnosti podrazumeva postupak kojim se utvrđuje trajanje svake pojedinačne sesije, odabrati vežbe koje će se primenjivati, utvrditi njihov redosled, trajanje i broj ponavljanja svake pojedinačne vežbe. Svaka sesija treba da počne vežbama za zagrevanje, da bi se intenzitet napora postepeno povećavao i da se svaka sesija završava postepenim „hlađenjem“ (12).

Adaptacioni odgovor organizma na redovnu fizičku aktivnost

Mnoga epidemiološka istraživanja su potvrdila da redovna, individualno dozirana fizička aktivnost štiti organizam od hroničnih oboljenja (9). Isto tako postoji raznolikost u primeni fizičke aktivnosti među nacijama. Južnoazijati manje primenjuju fizičku aktivnost nego Evropljani, što utiče na veću učestalost dijabetesa i kardiovaskularnih rizika u toj populaciji (41,42,43).

Pod uticajem redovne, individualno dozirane fizičke aktivnosti aerobnog karaktera može se povećati biološka efikasnost insulina. To se ostvaruje preko više mehanizama: povećanjem broja insulinskih receptora, njihove senzitivnosti i efikasnosti,

povećanjem stvaranja glukoznog transporta GLUT-4 na nivou ćelijske membrane mišića i masnog tkiva (16, 17).

Već nakon jednokratne fizičke aktivnosti prolazno se povećava broj i senzitivnost insulinskih receptora za 36% (18). Nakon dvonedelnog programa individualno dozirane fizičke aktivnosti kod ispitanika sa insulin nezavisnim dijabetesom, uz povećanje maksimalne potrošnje kiseonika ($\dot{V}O_2$)_{max}, utvrđeno je poboljšanje glikoregulacije i niz drugih parametara aterogeneze (19).

Utvrđeno je da jednokratna fizička aktivnost povećava insulinom stimulisanu potrošnju glukoze kod zdravih osoba, kao i onih sa IR. Ovi efekti su kratkotrajni, te se fizička aktivnost mora ponavljati i primenjivati redovno u dužem vremenskom periodu ako se želi povoljan terapijski efekat (19,20). Efekti redovne fizičke aktivnosti na IR utvrđivani su kod zdravih osoba i kod osoba obolelih od tipa 2 dijabetesa, nezavisno od starosti i stepena gojaznosti. Kod zdravih osoba redovnim aerobnim vežbanjem insulinska senzitivnost može se povećati do nivoa tipičnog za mlade sedaterne osobe i to nezavisno od promene telesne mase i strukture sastava tela (21,22).

Postoji određena raznolikost u proceni efekata primenjene fizičke aktivnosti kod bolesnika sa tipom 2 dijabetesa, koje bi mogle da se objasne različitim stepenom ispoljenosti IR ili metaboličke kontrole. Kovisto i De Fronzo su dokazali da primenom fizičke aktivnosti postoji poboljšanje periferne insulinske senzitivnosti kod tipa 2 dijabetesa merene kao glukozna potrošnja za vreme hiperinsulinskog euglikemijskog klampa. Tako Lampan i saradnici nalaze da fizička aktivnost kod osoba sa IR i tipom 2 dijabetesa sama za sebe ne poboljšava uvek osetljivost skeletnih mišića na insulin, već povećanje ($\dot{V}O_2$)_{max} najverovatnije predstavlja uslov za poboljšanje metabolizma glukoze i insulina (23).

De Fronzo je dokazao da smanjenje IR zavisi od bazalnog nivoa insulina, pre primene fizičke aktivnosti. Smanjenje insulinske sekrecije nakon primene fizičke aktivnosti izrazitije je u osoba sa inicijalno visokim nivoom insulina i C-peptida. Procenjuvan je i efekat fizičke aktivnosti u trajanju od 3 meseca na insulinsku sekreciju, bez promene u telesnoj masi. Visok nivo bazalnog insulina smanjen je usled poboljšanja periferne insulinske senzitivnosti. U odnosu na ovu grupu bolesnika, kod bolesnika sa tipom 2 dijabetesa i sa inicijalno niskim nivoom insulina, i pored visokog stepena IR, efekat fizičke aktivnosti na promene bazalne koncentracije insulina bio je znatno manji. Glukozna tolerancija kod svih bolesnika poboljšana je zbog povećane periferne insulinske senzitivnosti. U istraživanju gde je metabolička efikasnost merena određivanjem insulinemije tokom stimulacije u toku 5 sati OGTTa, već nakon desetodnevog programa individualno dozirane fizičke aktivnosti kod tipa 2 dijabetičara, dokazano je povećanje biološke efikasnosti insulina smanjenjem insulinemije i površine ispod stimulisane krive za 33,1% uz korekciju poznog hipersekretornog pika (24). Lampan i saradnici dokazali su da osobe sa tipom 2 dijabetesa imaju niži nivo ($\dot{V}O_2$)_{max} u odnosu na zdrave osobe (23,24). U stanju loše metaboličke kontrole kod

dijabetičara, fizička aktivnost ne poboljšava ni maksimalnu potrošnju kiseonika kao ni metaboličku kontrolu koja se, naprotiv, može i pogoršati, jer ovi bolesnici ne mogu da postignu dovoljan intenzitet fizičkog napora koji je nužan za postizanje povoljnih efekata (25,31,32,33).

Kod osoba obolelih od tipa 2 dijabetesa sa prvim stepenom gojaznosti, već nakon prve sesije vežbanja povećava se insulinom stimulisana potrošnja glukoze za 22%, a posle šeste nedelje programiranih mišićnih aktivnosti za 42% (26,34,35,36). Poboljšanje insulinske senzitivnosti pod uticajem programirane fizičke aktivnosti održava se samo 12 do 48 sati nakon poslednje sesije vežbanja, praktično gubi se nakon tri do pet dana mirovanja.

U većini radova ističe se da je povećanje insulinske senzitivnosti pod uticajem programiranog vežbanja aerobnog karaktera proporcionalno ostvarenom povećanju aerobne sposobnosti. Međutim, Erikson i saradnici su dokazali da 12-nedeljni program kružnog treninga pojedinih mišićnih grupa sa teretom i bez povećanja ($\dot{V}O_2$)_{max} utiče na povećanje insulinske senzitivnosti za 38% (27,28). Novija istraživanja ukazuju na to da fizička aktivnost sa teretom pojedinih grupa mišića, ako je pravilno odabrana i dozirana, može da utiče na smanjenje IR. Ovakve aktivnosti stimulišu mišiće na način koji se razlikuje od stimulacije aerobnog treninga i time za sada nepoznatim mehanizmima dodatno doprinose povećavanju insulinom izazvanu potrošnju glukoze. To je razlog zbog kojih se u okviru terapije IR sve više preporučuje kombinacija aerobnog treninga i kružnog treninga sa teretom pojedinih grupa mišića umerenog intenziteta, učestalosti tri do pet sesija nedeljno i trajanju svake sesije od 15 do 60min (28,29,30).

U istraživanju koje je sprovedeno 2000. god., primenom dvonedeljnog programa individualno dozirane fizičke aktivnosti kod gojaznih insulin nezavisnih dijabetičara, značajno je uticao na povećanje aerobne sposobnosti ($p < 0.05$) i smanjenje insulinske rezistencije ($p < 0.001$), izraženo u procentima za 96,7% (4,37,38,39). Uz povećanje insulinske senzitivnosti ostvareno je poboljšanje metaboličke kontrole, odnosno smanjenje glikemije našte, $p < 0.05$, za 26,43%, smanjenje koncentracije lipoproteinskih frakcija (triglicerida $p < 0.05$, odnosno za 21,3%, i LDL holestrola $p < 0.05$ za 16,43%) i smanjenje faktora koagulacije (X faktora $p < 0.05$ za 12,3%) uz ubrzanje fibrinolize i povećanje aktivnosti PAI-1 $p < 0.01$, odnosno za 30,8%. Program fizičke aktivnosti sastojao se od sesija hoda na tredmilu, 5 puta nedeljno, trajanja 35 min. Sesije su se sastojale od 3 dela: prvi deo – 5 min zagrevanja sa intenzitetom rada 45–55% ($\dot{V}O_2$)_{max}, drugi – trenažna aktivnost 25 min intenziteta rada 55–75% ($\dot{V}O_2$)_{max} i treći – hlađenje 5 min intenziteta rada 45–55% ($\dot{V}O_2$)_{max}. Rezultati predstavljaju doprinos iznalaženju što efikasnijeg modela fizičke aktivnosti za smanjenje insulinske rezistencije i uspostavljanju metaboličke kontrole kod insulin nezavisnog dijabetesa. Ovi ciljevi se mogu postići već nakon 14 dana programirane fizičke aktivnosti (4,37,38,39).

Efekat različitih tipova fizičke aktivnosti još uvek je nepoznat (40). U studiji Eriksona i saradnika, iz 2003. god., dokazano je da umerena i teža fizička aktivnost ili profesionalna fizička aktivnost, kao i rekreativna fizička aktivnost, dovode do smanjenja rizika za nastanak tipa 2 dijabetesa. Istovremenom upotrebom dva ili tri tipa fizičke aktivnosti značajno se smanjuje rizik od nastanka dijabetesa nego upotrebom samo jednog tipa fizičke aktivnosti. Smatra se da je optimalni terapijski pristup, kod gojaznih bolesnika sa tipom 2 dijabetesa, primena kombinacije fizičke aktivnosti i kalorijske restrikcije (41,42).

Zaključak

Saznanja o širokim preventivnim i terapijskim zdravstvenim efektima dostizanja i održavanja prosečnog nivoa fizičke sposobnosti velika su dostignuća savremene medicine. Svetska zdravstvena organizacija je, zajedno sa Međunarodnim udruženjem za sportsku medicinu, promovisala deklaraciju pod nazivom „Fizička aktivnost i zdravlje“ i ukazala na njen globalan značaj. Svetska zdravstvena organizacija takođe propagira svoja načela o primeni fizičke aktivnosti i dijetе u školama. Promoviše se upotreba zdrave hrane i primene fizičke aktivnosti kod dece u školama u cilju prevencije zdravlja i nastanka dijabetesa (30, 31). Teži se primeni programiranih fizičkih aktivnosti u cilju poboljšanja zdravlja u rutinskoj praksi (9).

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THERAPEUTIC ASPECTS OF INDIVIDUALLY MEASURED PHYSICAL ACTIVITY

Abstract: Insulin resistance (IR) with resultant hyperinsulinism is basically the origin of the development process from obesity to insulin-independent diabetes mellitus (NIDDM). This process contributes to a reduced physical activity that is manifested in a reduced physical ability. Under the influence of a regular individually measured physical activity of aerobic character, it is possible to increase biological efficiency of insulin and affect the process of early and evolutive atherosclerosis. Finding a more effective program of physical activity for preventing these processes is the goal of their preventive and therapeutic application.

Key words: obesity, insulin resistance, insulin-independent diabetes mellitus, physical activity, physical activity program

Introduction

The first written records about the effects of physical activity on health come from Kung Fu from ancient China and are about 500 years old. Only at the end of the last century the first scientific study on the impact of physical activity on health was published. To this aim, the criteria for the measured physical activity for health purpers has been established (1). Sedatery lifestyle prevailes in Western countries tending to spread over developing countries. A rise in chronic degenerative diseases such as cardiovascular, metabolic, hormonal, musculoskeletal system and diseases whose etiology may be associated with a reduced physical activity has been registered (1, 2). By definition, hypokinesia is insufficient level of active walking. The basic features of hypokinesy is a level of physical activity that is below the chronic irritation that allows the maintenance of functional capacity of most organ systems (3).

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Physiological characteristics of aerobic capacity

In practice, physical work capacity is often identified with aerobic capacity, and the maximal oxygen uptake (VO_2)_{max} which is expressed in l/min, ml/kg/min or Met's. The most important symptom of hypokinesy is a decrease in aerobic capacity which is followed by the decrease in physiological and morphological processes in the body, especially those that use oxygen as an energy source during submaximal work intensity (4, 5). A reduced physical activity causes morphological and functional changes in the body, leading to a decreased muscle mass, muscle tone and strength, reduced muscle capillary density and a number of mitochondria and oxidative enzymes. Reduction in myocardial mass results in a decrease in stroke volume of the heart with increasing heart rate. It also reduces concentration of lipoprotein lipase, and increases a total and LDL cholesterol, triglycerides, reduced HDL cholesterol. A reduced number, sensitivity and efficiency of insulin receptors leads to hyperinsulinemia and hyperglycemia (2, 5, 6). Recent studies have shown an association between decreased physical activity and increased incidence of lung cancer, colon, ovarian, breast and prostate cancer (7, 8-10).

It can be concluded that the effect of low level of aerobic capacity is independent risk factor for cardiovascular, metabolic and some malignant diseases.

To eradicate adverse health effects of physical inactivity it is necessary to achieve and maintain the average level of physical fitness. All age groups must do certain physical activity to maintain "physiological fitness," which implies the optimal performance of the metabolism of fats, carbohydrates, and body mass index and functional ability of the organism (11). People function, look and feel better when lead an active life (WHO 1998) (9).

Principles of programming physical activity for health purposes

Health effects of physical activity can be expected only when there are no contraindications for its use and when physical activity is adequately measured (12). Lack of physical activity will not cause adaptive responses necessary to achieve the appropriate health effects, while overdosed physical activity causes different forms of health damage. The major goal of physical activity for health purposes is to increase aerobic capacity (VO_2)_{max}. The program of individually measured physical activity is so designed to fit biological characteristics of a person, level of aerobic fitness and health status of program participants. This is a program of adjustment, and relates to the frequency, intensity and duration of physical activity with the use of general recommendations of the form of physical activity.

American College of Sports Medicine (ACSM) has set global principles modeling of physical activity related to the intensity, frequency and duration of physical activity of aerobic characters (13):

1. Exercise frequency: 3 - 5 days/week.
2. Exercise intensity: 60% -90% of maximal heart rate (HR max)² or 50% -85% of maximal oxygen uptake (VO₂max) and maximal heart rate reserve (HRmax reserve). Maximum heart rate reserve is calculated from the difference between maximum heart rate and heart rate at rest (HRmin)³ (Karvonen, 1957).
3. Exercise duration: 20 min - 60 min of continuous aerobic exercise. Duration depends on the intensity of activities so that low-intensity activity should taken longer.
4. Physical activities types: physical activities that engage large muscle groups are recommended, that can be carried out continuously and are aerobic by nature such as walking, hiking, running, jogging, biking, dancing, climbing stairs, swimming, skating and games of endurance.

In practice, the measure of intensity of load over the maximum increase in pulse rate (which is considered to be identical to the measure over (VO₂) max) is determined by the use of the Karvonen formula: $TP = k (fC_{max} - fC_{min}) + fC_{min}$, where TP = training heart rate, fC max = maximum frequency of heart rate (calculated by the formula 220 - age), fC min = value pulse in bed the morning immediately after waking. Value of coefficient k is from 0.5 to 0.85 when the training load doses range from 50% to 85% of maximal heart rate increase.

For parameters fCmin, fC max, and MPP (VO₂) max in each subject makes the individual "dosimeter" for the intensity is made in the following way:

- a. Using the Karvonen formula the value of training heart rate is determined that corresponds to intensity of work ranging from 40% to 80% MPP. During the sessions of physical activity we applied intensity of load on a treadmill to match the intensity of load of 45% - 55% in the phase of warming and cooling, and 55% - 70% in the phase of exercise session.
- b. With regard to the intensity of exercise expressed as % MPP match %(VO₂) max, for each value of training heart rate in the range of 40% -80% MPP we calculate in energy prices (VO₂) max is expressed in kcal ($1 / (VO_2) = 5$ kcal).
- c. Based on the analysis of memory pulses in each session of physical activity, intensity of work performed is expressed in the average values of TP and

² HRmax = 220 - age.

³ HRmin - morning pulse rate was measured in bed just after waking

% MPP (% (VO₂) max) and the energy cost of sessions in the total calorie consumption.

The initial level of physical fitness is an important factor in dosing exercise intensity. Individuals with low levels of physical ability can achieve significant training effects even with the training heart rate at 40 - 50% HR max reserve. Those with higher levels of aerobic fitness, require higher intensity of load. Lower to moderate intensity of physical activity of longer duration, especially recommended to adults, sedentary due to the fact that such efforts are easier to bear and due to the possible risks caused by high intensity physical exertion (13).

Multiplying the average intensity of effort in kcal /min and its duration in minutes, we get the total energy cost of work performed in each exercise session. It is believed that the energy requirements of individual training sessions within the exercise to increase aerobic capacity, should not be less than 150kcal (13, 14).

Modeling the program for physical activity means the way to determine the duration of each session, choose exercises that will be applied, to determine their sequence, duration and number of repetitions of each exercise. Each session is to begin by warm-up exercise, to gradually increase the intensity of effort and to end each session with a gradual “cooling” (12).

Adaptive response to regular physical activity

Many epidemiological studies have confirmed that regular, individually measured physical activity protects people against chronic diseases (9). Also, there is a diversity in the application of physical activity between nations. South Asian apply less physical activity than Europeans, which affects the higher frequency of diabetes and cardiovascular risk in this population (41-43).

Regular, individually measured physical activity of aerobic character can increase biological effectiveness of insulin. This is accomplished through several mechanisms: by increasing the number of insulin receptors, their sensitivity and efficiency, by increasing the production of glucose transporter GLUT-4 at the cell membrane of muscle and adipose tissue (16, 17).

Already after a single lap of physical activity the number and sensitivity of insulin receptors are increased by 36% (18). After a two-week program of individually measured physical activity in patients with insulin-independent diabetes an increase in maximal oxygen uptake (VO₂)max was determined to improve glycemic control and many other parameters of atherogenesis (19).

It was found that single physical activity once increases insulin stimulated consumption of glucose in healthy individuals and those with IR. These effects are short-lived, so physical activity must be repeated and applied regularly over a long

ger period of time to have a favorable therapeutic effect (19, 20). Effects of regular physical activity on the IR, were assessed in normal subjects and patients with type 2 diabetes, regardless of the age and obesity. In healthy individuals, under the regular aerobic exercise, insulin sensitivity may be increased to the level typical for young sedentary persons, regardless the changes in body weight and body composition structure (21, 22).

There is a diversity in the evaluation of the effects of the applied physical activity in patients with type 2 diabetes, which could be explained by the variety of the level of IR or metabolic control. Kovisto and De Fronzo have shown that applying physical activity improves peripheral insulin sensitivity in type 2 diabetes measured as glucose consumption during hyperinsulin euglycemic clamp. So Lampan et al. found that physical activity in subjects with IR and type 2 diabetes alone does not always improve the sensitivity of skeletal muscle to insulin, but the increased (VO₂) max is most likely the condition to improve glucose metabolism and insulin (23).

De Fronzo has proved that reduction of IR depends on basal levels of insulin, before the application of physical activity. Reduction of insulin secretion after administration of physical activity is more pronounced in patients with initially high levels of insulin and C-peptide. The effect of physical activity for 3 months on insulin secretion was measured, without changes in body weight. The high level of basal insulin was reduced due to an improvement of peripheral insulin sensitivity. In relation to this group of patients in patients with type 2 diabetes and with initially low levels of insulin, despite a high degree of IR, the effect of physical activity on changes in basal insulin concentration was significantly lower. Glucose tolerance in all patients was improved due to increased peripheral insulin sensitivity. In a study in which metabolic efficiency was measured by determination of insulinaemia during stimulation for 5 hour OGTT, after a ten-day program of individually prescribed physical activity in type 2 diabetes, it was found that biological effectiveness of insulin reduction and the area under the curve stimulated increased by 33.1% with the correction of late hypersecretory peak (24).

Lampan et al. have shown that people with type 2 diabetes have a lower level (V_{O2})max compared to healthy subjects (23, 24). In a state of poor metabolic control in diabetics, exercise does not improve maximum oxygen consumption or metabolic control, which may worsen, because these patients can not reach a sufficient intensity of physical effort that is necessary for achieving positive effects (25, 31-33).

In type 2 diabetic patients with first degree of obesity, after the first session of exercise, increased insulin stimulated glucose consumption by 22% and after six weeks of programmed muscle activity by 42% (26, 34-36). Improvement of insulin sensitivity under the influence of programmed physical activity only 12 to 48 hours after the last exercise session, virtually disappears after three to five days of rest.

In most papers it has been suggested that the increase in insulin sensitivity under the influence of programmed exercise of aerobic character is proportional to the increase in achieved aerobic fitness. Eriksson et al. have shown that a 12-week program of circuit training of individual muscle groups with load, without increasing the (VO₂) max, affect the increase in insulin sensitivity by 38% (27, 28). Recent studies suggest that physical activity with load individual muscle groups, if properly selected and measured can influence the reduction of IR. These activities stimulate muscles in a way that is different from the stimulation of aerobic training and that for yet unknown mechanisms contribute to further increase the insulin-induced glucose consumption. This is the reason why the IR in the treatment is more recommended combination of aerobic exercise and circuit training with the burden of individual muscle groups of moderate intensity, frequency of three to five sessions per week and duration of each session from 15 to 60 min (28-30).

In a survey conducted in 2000 using a two-week program of individually measured physical activity in obese insulin-dependent diabetic patients, significantly increased the aerobic capacity ($p < 0.05$) and decrease insulin resistance ($p < 0.001$) in percentage of 96.7% (4, 37-39). Increase in insulin sensitivity improves metabolic control, decreases blood glucose $p < 0.05$ by 26.43%, decreases plasma lipoprotein fractions - (triglycerides $p < 0.05$ by 21.3%, and LDL cholesterol $p < 0.05$ by 16.43%) and reduces coagulation factors (factor X $p < 0.05$ by 12.3%) with an acceleration in fibrinolysis and increased activity of PAI-1 $p < 0.01$ respectively by 30.8%. The physical activity program included sessions of walking on a treadmill, 5 days per week, duration 35 min. The sessions included 3 parts: The first part of 5 minutes warming with intensity of 45 -55% (VO) max, the second part training activity 25min work intensity of 55-75% (VO₂) max and the third part cooling 5 min intensity of 45 - 55% (VO₂) max. The results contributed to the finding of more efficient models of physical activity to reduce insulin resistance and the establish metabolic control in insulin-independent diabetes. These goals can be achieved even after a 14-day of the programmed individually measured physical activity (4, 37-39).

The effect of different types of physical activity is still unknown (40). The study performed by Eriksson et al. in 2003 proved that moderate and severe physical activity or occupational physical activity and recreational physical activity lead to a reduced risk of type 2 diabetes. Simultaneous use of two or three types of physical activities significantly reduces the risk of diabetes than the use of only one type of physical activity. It is believed that the optimal therapeutic approach in obese patients with type 2 diabetes is application of a combination of physical activity and caloric restrictions (41, 42).

Conclusion

To know about the wide preventive and therapeutic health effects of obtaining and maintaining the average level of physical fitness is a great achievement of modern medicine. The World Health Organizations, together with the International Association for Sports Medicine, promoted the declaration titled "Physical Activity and Health" and pointed to its global significance. The World Health Organization also promotes its principles of the application of physical activity and diet at schools. The use of healthy foods and increased physical activity among school children are also promoted for health care and prevention of diabetes (30, 31). Our aim is to implement a programmed physical activity in order to improve health (9).

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