**Advancements in Diabetes Seminar**
**Exercise Update for Diabetes Treatment and Prevention Specialists**

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Ralph LaForge:

I'm consulting faculty now at Duke University in the Lipid Clinic, the Cholesterols Disorders Clinic. But I'm very involved with the National Lipid Association and on a number of committees. And the biggest project I have right now is exercise and statin disorders -- I'm sorry, lipid disorders, and exercise and statin intolerance. So that's been taking up most of my professional time. So I am in Durham, North Carolina.

And at this point, I think what I'll do, I don't think we'll go the full 90 minutes, but I would like to the answer questions as they come up unless they start compounding themselves, and then I'll save those for the end. So if you have questions in real-time, I think we've got enough time to do this, and they're appropriate to that particular slide's information, I will go ahead and answer them in real-time.

So without overlapping too much, I'm trying to keep most of this information different than what we've done before, or at least an update, exactly what we'll do today. We'll be covering the new exercise screening guidelines by the American College of Sports Medicine. This is for patients that are fairly sedentary and want to start an exercise program of at least moderate intensity. What are the new guidelines? And they are different. And there's some overlap with the past, but they are quite different. And this will impact to some degree with IHS and DDTP will be using in the future for their pre-participation guidelines or exercise programs.

For the first time, we'll talk about actually quite a bit of research in the last four or five years, on pedometers and accelerometers or fitness activity trackers. What did they do? Did they do it right? Are they valid? Answer is, some are, some are not. Most do a fair job, but we'll talk about that in some detail.

The value of just light intensity exercise. And that's physical activity less than three METs. Can you believe that? Just milling around, doing some light work at home, et cetera. Surprisingly there is benefit from this that's quite impressive, versus no activity.

When we talk about fitness versus physical activity, I hear a stir around the words "fitness and cardiovascular and cardio respiratory fitness." It is not the same thing as physical activity. And we use those interchangeably. I hope I can discriminate the two in just a moment or two.

How to predict the energy cost of activities. The reason why -- not so much for weight loss, although that's part of it, but mainly most of the -- at least in our patients in diabetes care and cardiology, most of the research relates the total caloric energy expenditure throughout the day no matter what you're doing as a better connect with mortality than just fitness. Although both energy expenditure and predicting the caloric cost is a little bit of a roulette game, it's very difficult to do. I'm going to give you some rules of thumb to do this. And we're going to discriminate between net and gross energy

expenditure which is a big difference. But what we want to do is predict or at least estimate net caloric cost of household chores or stair-stepping or whatever it may be.

And then assessment of physical activity as well as cardiovascular fitness. These are key outcomes indicators for the DDTP for your outcomes reporting measures, for your grants, grant reporting. Yet I am not knowledgeable of exactly what fitness tests you do. I've not ever seen that before. How do you measure fitness in the IHS? Maybe you do, maybe you don't. The same thing, how do you estimate physical activity? Probably just self report. But we hopefully will give them some light that's very practical on that. Then there's a select research topic or two that we'll talk about.

Now, I'm going to give you the answers to all of those issues right here. So if you had to go really quick and get on an airplane, you only had 90 seconds to review this whole program, I'm going to give it to you right now. And this is just a very elementary point summary of each of those research topics:

- The new guidelines for assessing physical activity has eliminated measuring cardiovascular risk factors. They've eliminated doing exercise stress tests. We'll come back to that.

- Second point, fitness trackers record steps the best and are quite lousy at measuring with any accuracy energy expenditure or distance. That is so well-researched. Even this week, there were two papers on this.

- Light intensity exercise generates great cardiometabolic benefits. I shouldn't say great, but significant cardiometabolic benefits.

- Fitness best predicts risk of, actually, coronary disease; and moderately so, diabetes. But physical activity best predicts behavior. We're going to underscore physical activity as probably the thing if you had a choice as an outcomes indicator. You are better off in the long run measuring or estimating physical activity, especially the energy expenditure. As I said earlier, if you're trying to estimate the caloric cost of a particular workout or a whole day's activity, you're best considering the net energy cost. And you have to consider energy compensation. That is for people who -- many of us actually eat more when we get fitter or when we do more exercise. You have to somehow allow for that. And you also have to somehow -- we'll show you how -- account for the conservation of energy. That is for those of us that work out really hard are more apt to conserve activities of daily living for the next three or four hours after the workout. So those are important contaminates of accurate energy expenditure measurement or estimation.

- Actually, this next topic, I actually pulled those slides out. I didn't know if I had time or not. If we have time, I'll talk about this. It is true that statins, especially the higher-intensity statin therapy, these are drugs that lower cholesterol. In fact, they're the more popular drugs in the world, believe it or not, many of your patients, if not all your patients are on statins, can affect exercise performance. But the good news is it only affects, as a rule, peak exercise performance. Anything less than peak is not generally affected, but there are a few caveats to that. So if we have time, I'll address this. In the Anchorage or the Alaska Diabetes Conference in a couple of months, we're going to spend a whole hour on this.

Okay. So that's sort of the whole next 70 to 75 minutes in a nutshell. And again, if you have questions throughout, go ahead and type them in. I'll try to get to as many as I can in real-time. Otherwise, I will certainly wait to the end to get to the ones I don't get to in real-time.

Okay, a year ago, the American College of Sports Medicine, which pretty much drives most of the standards throughout -- actually, throughout the world, but especially in North America, including the American Heart Association, et cetera, on the tools to use to screen patients before they do especially

higher-level exercise programs. If you notice on the DDTP website under Physical Activity, under Clinical Practice Recommendations, you will notice and you will see this in the Quick Guide Cards, a very specific link, I've circled it here, to the existing 2010 ACSM Guidelines for Screening Patients. And I'm going to show you the summary of what the 2010 Guidelines which is on the IHS website actually says. And I won't go into this in great detail, but it says you stratify patients that are starting an exercise program either low, moderate, or high-risk." When we say low, moderate, or high-risk," we're talking about low risk for cardiovascular complications in the exercise program, or high risk for exercise generated complications during your exercise program.

Well, I think I circled this, yes. So the thing that is the issue that has been taken away is we no longer are using or counting risk factors. Not for estimating cardiovascular disease, but for predicting detrimental or untold cardiovascular outcomes during the exercise session or immediately following the session, okay? We've eliminated that. I should say ACSM has eliminated that and they've also eliminated stress EKGs. And they leave that up to the provider. But no longer is it "carte blanche" on all guidelines to do a stress EKG in those patients that are going to do more vigorous exercise. There are just too many errors and the data is all over the map in the utility of stress electrocardiograms, with exception of patients that already have cardiovascular disease. We're going to go back through this in some detail.

Yes, someone had asked, Lauren had asked, "Is there a recommended amount of steps to take daily to be considered light activity?" No, but it's going to be around 3,000 to 4,000, okay? We know that the CDC now says you should be getting a minimum of 5,000 steps per day regardless of what the activity is, and anything below 5,000 is now considered the sedentary lifestyle index. A segment below that 5K point is what would be considered light. And I'm going to guess is around 2,500 to 3,500, somewhere in there. But you're probably not going to see in print anywhere. I'm just extrapolating, okay?

So here's the new model for physical activity program screening that we'll eventually put up on the DDTP website probably as a separate link under Physical Activity.

Now, I'm going to show you three slides. And I'm going through this. This is the logic model. If you notice, we've turned the arrow on here. If you notice, if the patient participates in regular exercise already, that is at least three days a week of something close to moderate, if he or she doesn't versus does, you have a different pathway of questions to clear the patients. So don't worry about reading this now, but the next two slides are going to hallmark, if they say no, if they say yes to if they participate already in regular exercise and they come to you for an exercise plan.

So the next slide will show that first segment. No, they don't participate in regular exercise program. Then you go through a series of questions. I'm going to make that more simple in just a moment. And then based on your decision, you can either order a stress EKG, which in most cases, you're not going to do, or you can, and that will determine the value or the amount of exercise that you do.

The next slide is just if the patient already exercises. If the patient already exercises, say yes to that question. Then there's a different pathway you use to screen them. I will show you that in a simpler than this black diagram. But the reason I've put these last three slides up, you can print those up and that is what's going to be ultimately hopefully on the DDTP exercise or physical activity link website.

So, what has changed? What has changed since 2010? Three things. An expert panel, and I mean people like Paul Thompson and Murray Mittleman. These people have been the world experts in exercise-generated complications, especially cardiorespiratory complications. They've been around for many years. The three key things you must know before someone starts is what they're doing now; the presence of signs or symptoms of known metabolic, renal, or cardiovascular disease, and the desired intensity of exercise. Notice, there's nothing about cardiovascular risk factors, okay?

Now, I'll go through these individually, these three, current level of activity, presence of symptoms or signs, and desired planned exercise intensity. I'm going to spend some on the symptoms because, understand, we're not just talking about chest pain, but what we call "chest discomfort equivalence" that can be prodromal to an impending event during exercise. We'll come back to this in a moment. Now, before I get to these three, let me just show you why we pulled out asking questions about cardiovascular risk factors in the patient.

Cardiovascular risk factor assessment in pre-participation screening is out. Why? Because the high prevalence of cardiovascular risk factors among adults combined with the extreme rarity, and it is rare, of exercise-related SCD, that means "sudden cardiac death" or an acute myocardial infarction. The presence of risk factors, believe it or not, does not and can very seldom predict those events during exercise. That's the number-one reason why we pulled out having to estimate and put in the pathway the number and the presence of risk factors. The second reason is recent or evidence suggests that conventional cardiovascular risk factor-based exercise pre-participation health screening may be overly conservative because of the high prevalence of cardiovascular risk factors. Like everybody has got at least one risk factor. In the DDTP, our patients are going to at least two, diabetes being one. So everybody would be falling into the same bracket, practically, needing a stress test, and we know that's not necessary now.

Okay. So, the big three. Current level of physical activity. What I would recommend and what ACSM recommends, at least the number of days per week; none, one to two, three to four, five days a week of getting something close to at least moderate exercise. Murray Mittleman, years and years and years ago, showed those who get five or more days a week of at least moderate exercise, the relative risk of an acute myocardial infarction was enormously lower than those who got three to four, one to two, or nothing. That has stood the test of time and research since they did this study in 1993. That's a very powerful statement. And that's why it's now the number-one question you ask patients, to self-disclose their current level of activity.

And here's a statistic for you. The risk of acute heart attack for habitually inactive individuals or sedentary individuals was 50 times higher than for the most physically active individual. When we say the most physical active, we're going to make an exception for those people who obsessively over-exert, okay? Those people who are on the top end and over-the-top of not only in the days per week, but the intensity. Because they actually fall back into a risk category of at least moderate to high risk for cardiovascular complications.

So, regular exercise reduces the 24-hour risk. When you say "risk" we mean having a heart attack or an equivalent of a heart attack within 24 hours of the last exercise session. That's really what we're talking about here. We're trying to prevent exercise-generated cardiovascular complications.

Just on a side, the term "Medical Clearance" now has replaced "Specific Recommendations" for medical examination or exercise testing. And I think that's already in the DDTP-IHS lingo. "Medical Clearance" is the term they use rather than -- what that infers is that the practitioner or the medical professional could be a nurse, mid-level, could be a pharma clinician with proper training, or certainly a physician, that deemed the patient did not need a stress EKG just based on their clinical judgment and what the patient's history was like.

Okay, the next of the big three, the presence of symptoms. Really, we talk about this very elementarily in many papers and certainly many presentations. But I really want to spell out in some detail what ACSM, three-pages of these categories of issues that if they're present, you need to be wary about how the volume and intensity of exercise the patient goes through. For example, the next three slides we're going to not read now, but they're presented for you so you can print these out, and these are right out of the text from the ACSM guidelines. The one I want to talk about the most is pain discomfort or other angina equivalent, tight chest discomfort, neck, jaw, or arms or other areas that may result from the heart not getting enough oxygen, okay?

Now, rarely is prodromal cardiovascular-related heart discomfort a pain. It's most characterized as a discomfort or a feeling, and a radiating feeling, not just in the chest or neck or jaw. It comes with exertion and is relieved by rest. In other words, quite reproducible there. The character of that discomfort can be constricting, squeezing, burning or heaviness. This is what must be queried when interviewing a patient that may already have diabetes, obesity, they're on multiple medications, they also have hypertension, and then they have COPD, et cetera. You want to make sure, when they do exercise, at least moderately, they don't have these symptoms. The location does not have to be in the chest, but most often tends to be substernal, across the mid-thorax, anteriorly in one or both arms.

I've had patients in cardiac rehab, if you've been in rehab at all or had the experience of being in a cardiac rehab program as a professional, you know that once or twice a year you get patients that get angina equivalence in their jaw. It comes with exertion or more vigorous exertion and is relieved by rest. Okay. I won't go any more on this, but I just wanted to specify the character of chest discomfort as something we look for. Shortness of breath, dizziness or syncope or orthopnea, which would be dizziness or shortness of breath at rest, okay?

We all get shortness of breath, of course. We're talking unusual shortness of breath with minimal effort, where they can't quite catch their breath. Anytime a patient gets dizzy, light-headed with exertion or it's relieved by stopping exertion, really in cardiology, what they try to rule out is that dizziness or light-headedness is due to an exercise-generated dysrhythmia, a disturbance in cardiac rhythm. And it's not always that by any means, but that's what we want to ensure. That's one reason if that occurs the patient must be evaluated by a physician first, not necessarily always a cardiologist.

And then I won't go to the rest of these, these are a little less important, but ankle edema, palpitations, like say a patient gets irregular heartbeats and feels them in his chest and palpates them. Or a very rapid heartbeat that goes from 75 beats per minute to 150 beats per minute just taking the first walking step. That's probably PAT or one of these syndromes, but it needs to be evaluated by a physician. A tightness in the lower extremities; intermittent claudication, as they say; and then known heart murmur and others. But the chest discomfort is the main key here that we want to rule out. And again, all this detail for you in writing is really for your own use, you can print that out.

The last of the big three is, what do you plan for the patient? And keep in mind, a patient who is sedentary or gets very little daily or weekly exercise, three or four METs of activity is 90% of their effort level, they're in lactate threshold, they're in what used to be called anaerobic threshold, by the fifth step of walking up a small grade. Keep in mind that vigorous intensity, which is defined as 60%, not of your max heart rate, but your max effort level, 60% of max heart rate to about 75% of max heart rate, so 60% of max effort level for some people who are sedentary doesn't take very much.

So what we know now is that sudden cardiac death and acute myocardial infarctions events have largely been in response to moderate or vigorous exercise.

However, there are two other caveats. When someone who does moderate, maybe even short-of-moderate, and they do it for prolonged periods of time and are not used to doing it for just 20 minutes and suddenly someone takes them out on a trek that's eight miles and they're not used to that, that's another source. That's called "long-slow distance" and it's the duration that could be a factor.

The other caveat would be sustained heavy-resistance exercise. They're not sustaining 60% of max effort for the whole 45 minutes of doing weight training or resistance exercise, but what they're doing, maybe once or twice a minute, they are going to failure, they're going to very high resistances they are not used to it. So those are two caveats that might go beyond these two.

I'm not trying to be overly discriminating or overly concerned that we're going to see all of this risk in our average patient. I'm just trying to have you rule out worst-case scenarios when you start an exercise program or some or advise a program for someone who's been formally sedentary.

Just to recap, this is the last slide in this section. Individual's current level of activity; presence or signs or symptoms in known cardiovascular, metabolic, or renal disease; and desired exercise intensity. No general need for a stress EKG, no counting of the risk factors. You've already counted the risk factors, that's in the chart. You've already estimated the risk of cardio metabolic disease, that's fine. But you don't need to estimate or calculate the risk factors and measure them for predicting exercise-generated cardiovascular issues.

Let me see if there's a question that I can answer. There's a question by Amber that says, "Do you have any idea when the updated IHS Guidelines for Exercise --" oh, it's in writing right now. The tenth edition, the ninth or tenth, I think it's the ninth, it's hard to know that, is being written right now. And it's been re-written and re-written. So probably the first quarter of 2017, Amber, when the new guidelines will be out. And I believe these pre-participation screening guidelines will be in them.

And Julie asked, "Would you say that it's okay for a 51-year old man who had open heart surgery, bypass surgery, and two to three stents a year ago, play basketball or run?" Boy, the question, the answer to that is, "Basketball and run, how hard?" Competitive adult league basketball? Probably. But if it's a competitive adult league basketball, or they're going to be running on average above 60% of their max, I would probably get a stress EKG first. Or order one and have it sent to whomever in your clinic. And your clinic may not do stress EKGs but someone does. I would probably error on that, if someone is planning to go on a more intense exercise. Julie says, "He got hit in the chest a week ago." I may put the quiet on much exercise from the next week after that. But I would need more information to do appropriately answer that question, really.

Okay, let's talk about pedometry and physical activity trackers. Oh my God, there's so many. I have lost total track. There's around 800 on the market, and about 12 dominate. I'm going to show a lot of information here. When you look at the -- my pointer is not working right now. Oh, there it is. You have a range of very inexpensive pedometers like the Accusplit which is one we used for a lot of studies, it's a simple pedometer the 2720 it's like $18 or $20, all the way to an ActiGraph which is about $500. It's an accelerometer, it measures motion in all three planes. We don't need accelerometers, at least the higher-end accelerometers. Patients flushes those down the toilet, believe me, they flush them down the toilet all the time by accident, flipping them off their beltline when they're in the bathroom. You don't want to do that to an accelerometer.

So the ones that are most used for clinical purposes are the Omrons, the New-Lifestyle, the Accusplit pedometers, seem to be the best engineered. But Fitbit has come a long way as well. As well as you all know, on your Android or your iPhones you've got multiple apps that do a pretty fair job at estimating steps -- really, they do -- but a horrendously lousy job at estimating energy expenditure, or even distance. And you can take that to the bank.

So what we found, when you just look at some of the newspaper articles that synthesize a lot of the studies like you saw MedPage earlier this year, new evidence suggests that fitness trackers don't actually track fitness. Well, misuse of the word "Fitness," this should say, "Fitness trackers don't actually track fitness." It should say that, "Physical activity trackers don't actually track physical activity." That's what it really should say.

And so, the long and short of it is the better trackers measure footsteps and step counts far better and more accurately than they can do anything else. We've known that for some time. Here's a very telling study from Tokyo. And the reason this is important because is Haruka Murakani with his friend who's deceased now, Dr. Hatano who first came up many years ago with the 10,000 steps a day program. Haruka is one of his colleagues. What Haruka did here is, in just about 20 patients, looked at 10 or 12

different physical activity trackers, all pedometry, they're worn on the arm, on the wrist, or on the belt line. If you look right here, it standardized everybody wearing, they all wore these devices, sometimes at one time and some independently. They did standardized exercise. When you look at the spread of energy expenditure, for each device, you can see that the Withings O2 Pulse were estimating 1,800 calories a day and the Omron calorimeter was estimating 2,200 almost 2,300 steps a day. So quite a dispersal, 30% between each one of them, in estimated energy expenditure.

They looked at three living days. That just means it wasn't standardized. They just let them go out for a full day, including evening, and let them just wear all of these devices, every single one of them underestimated energy expenditure compared to the reference. And the reference was actually measured oxygen consumption with a portable device actually measuring it. So even the best more expensive devices looking at just free living, "Do this, do that, go to the work, make a workout, drive your car, whatever else," that's called free living, all underestimated energy expenditure, at least when they looked at these particular devices. And these are certainly just a small percentage of all the devices out there.

And what Murakami did, just look at this, can you believe this? Look at all the devices, all the devices on at one time. Now, scientifically, they probably contaminate each other because so many of them are rattling, push up against each other's trigger devices or accelerometer. But still, I think it was useful information. But that's exactly what each of these 19 patients were doing, measuring in most cases, wearing all the devices at one time. I'll come to your questions in just a moment.

So what Murakami concluded was essentially all wearable devices underestimated total energy expenditure under free living conditions, and significantly underestimate energy expenditure. Keep in mind that the utility of all fitness activity trackers in the clinic setting is to measure total daily, not just a particular workout. They all stack up pretty good at measuring a mile walk, believe it or not, in terms of steps. But looking at the patient's response to these trackers over the course of a day, the 24-hour period, they're off the chart in terms of agreeing with each other quite significantly.

There's another patient at Ball State University, Indiana. Ben Nelson and others looked at Fitbit's One, the Zip, and the Flex. The Fitbits rule the wrist-worn activity trackers as you I'm sure know. Probably most of you are wearing one now or one the like the Fitbit on the wrist. All of these monitors predicted energy expenditure within 8% of the COSMED. That's a wearable device. I'll show you a picture of in a minute where you wear this basic device on the back that measures oxygen uptake. And even that, COSMEDs have error as well, but it is as close to reality as you can get for actual measured expended energy. So basically, what they found, all PA monitors that they tested predicted energy expenditure within 8% for sedentary activity, but overestimated in this case energy expenditure about 16% to 40% during ambulatory activity. This wasn't just a 24-hour period, but ambulatory activity in the house or at work.

So the long and short of what Ben had to say about this was consumer-based physical activity monitors should be used cautiously for estimating energy expenditure. All they provide are accurate measures of steps for structured inventory activity similar to validated pedometers. And that's pretty much my bottom line to this section of the presentation. And this is just a quick look at some of these activities. And for those of you that have not used a Fitbit, it looks like this, different colors. Fitbit Ones can be worn on the belt. Fitbit Zips can also worn on the belt, et cetera.

I will say that one of the pieces of advice I'm going to give you to read as an outcomes reporting measure is a pedometer step count. Most of the newer pedometers now have seven-day, thirty-day, and one-year recalls. So in theory, they can download their weekly step count and give you that information every week since they last reported to you or ever the email et cetera. That right now is going way to the measure between visit physical activity, not so much fitness.

In Ben's study the referent for how well the Fitbit and others compared to just a simple pedometer worn on the belt, the simple pedometer worn at the belt was the Omron. The Omron has about five or six different models of pedometers. They all have been well tested and are quite accurate in this particular study. And as I said, to measure actual energy expenditure, according to Ben Nelson's study I just showed you, can you believe they had to wear this so they can measure oxygen uptake, therefore they can measure CO2 production, oxygen uptake?. Therefore, they could pretty much give a direct measure of caloric expenditure. So, they didn't estimate VO2, they actually measured it while these subjects were actually wearing the physical activity trackers.

To put it all together, as I said earlier, in regard to ambulatory activity, excluding cycling of course, all consumer-based PA monitors significantly overestimated energy expenditure for a particular activity -- I'm sorry, for the whole day's activity. These findings of the study indicate that consumer-based PA monitors average for tracking the energy expenditure and steps is dependent on the type of activity, of course. And the small checkmark here, this is really the important part to say consumer-based physical activity monitors do not provide accurate estimates of energy expenditure and should not be used for estimating caloric expenditure.

Just a couple of -- these were not scientific studies, but what they did, Leonard Ross form Arizona State looked at these five pedometers or wrist-worn activity monitors and just looked at, in one day, wore all four or five of these in one day, and looked at the difference over the course of the day between the Nike Fuel, for instance, and the Stride Play. So 8,600 steps for the Nike Fuel, and the Stride Play 16,500 over the course of the day, just looking at the step count. Day two saw just about as big a spread. Just to make sure, they repeated the same trend. Look at the spread here of the course of the day, these wrist-worn activity trackers.

Now, if they had used four or five belt-worn pedometers, they would have seen a tighter relationship. I don't have that data to show you, but that has been published several times over at the University of Tennessee. And Catrine Tudor-Locke has published data showing that wrist-worn pedometers of different manufactures worn on the same side on the beltline are more in agreement over the course of the day than the wrist-worn activity trackers.

Now, if you restrict what Ross did to restrict these patients, they were testing these five wrist-worn activity trackers, they walked on the treadmill for ten minutes at a consistent pace. The Nike Fuel, the Jawbone, the Fitbit One, the iFit, Stride Play, and the Fitbit 2 and the Fitbit Zip pretty much were in agreement for a 10-minute walk when you restrict it to a short period of time and that's all you're doing. But that's not what we're doing at IHS for most patients. We're looking at all activity over the course of the day, or the wakeful day, I should say. So that's really a key thing.

Here's one other. I forget her name, but she publishes this on her website, Sandra -- whatever her name is -- from Reno, Nevada. Again, just looked at a one mile walk, but this has been my experience to, wearing four or five different pedometers or wrist-worn activity trackers, and found a pretty good relationship on a mile walk between the Jawbone, a pedometer like an Accusplit or an Omron, Fitbit Flex, and the Nike All pretty much about 2,000 steps per mile. And isn't that the case. It's about 2000 steps per mile for most patients. We've used that as the standard for many years. But that's just a mile walk, so I don't think it's a problem with the accuracy between wrist-worn or waist-worn pedometers. And these are just pictures of these different devices.

Here's another study from Australia where a Fitbit Flex overestimated energy step counts in females by 556 steps per day. We're not talking about energy expenditure here now. We're talking about step counts, an overestimated step count in women over the course of the day; and in males, about 1.400 per day; looking at 48 cardiac patients.

So this is the bottom line. Just about a year ago, there was a systematic review of 22 different studies looking at this trend that we've been talking about for the last 10 minutes. And the trend, bottom line, is

this. The systematic review indicated higher validity of steps, fewer studies on distance and physical activity, and lower validity per energy expenditure. Looked at in a more simple way. From a clinic perspective, steps are most reliable, foot strikes and distance is less reliable. Energy expenditure measurements by any of these devices worn on the wrist, on the pocket, on the ankle, or on the waist, are quite unreliable for measuring caloric expenditure. If that's in fact what you're incentivizing the patient to do. You may not be doing this, but you can believe the patient is probably very aware of it and maybe thinking about it.

And keep in mind, one reason we like steps, and you've probably heard me say this before, one reason I like steps is because of the next slide. Each step represents an AMP kinase activation, an enzyme in the muscle. Just like metformin and many diabetes and other drugs do the same thing, especially Glucophage or metformin. Each intentional foot strike represents an AMP kinase activator. And that's really why I like the steps being the equivalent of AMP kinase activation, because that is so related to improving insulin sensitization, which is very important.

Just as an aside, the next generation of physical activity tracking is going to merge very accurate GPS devices with pedometers. Actually, Garmin has already done that, but they really didn't. They do not have a reliable pedometer. They've got a fairly reliable GPS mechanism. But just to show you, the newest generation being tested now is a device called the GlobalSat. The GlobalSat is a device that looks like a pedometer. And they just finished a study a month ago in the Journal of Applied Physiology, the first study to actually characterize the direct relationship between global positioning, speed, and grade -- no one's ever done the speed and the grade you're walking up or down -- to the metabolic cost of activity.

So I'm estimating probably, I don't know who's going to be doing this less expensively for most people's use in the clinic in the future, but you can believe in time the price is going to come down on these devices in probably I'm going to say the $40 to $50 range. Now you've got something to really enter the chart. It's a little more accurate than what we used before in terms of not just measuring steps but distance. The Chinese already have a device called the Xiaomi which has not been tested yet, at least in our country, that reportedly does this, a very accurate GPS device tied to step count. But like I said, this is more in the future than anything else.

So, again, for those of you that do incentivize patients to use pedometers and the Fitbits that do calculate or estimate energy expenditure, I would downplay that to them and I would up play the importance of foot strikes. Just the movement, just the movement of activity. And that's in fact what they do best.

What's the value of light physical activity? And I'll just leave this as a reference for you. But what I mean by light is here behaviorally talking about light, feels easy, you can easily carry conversations and singing, these are what will be considered light. There have been several papers in the last year on the value of light activity. Now, again, what we mean by light, if you compare light to cross-country skiing which is at the top of the ladder in terms of metabolic energy expenditure, light activity is between one and a half and three METs, probably closer to 3 METs, walking at slow to moderate pace.

So here's a paper by Kasha Dickie at Cape Town, South Africa that looked at South African women who were recruited to the study. They did all types of things at different stages of the study, measuring both light and then in a separate time moderate and vigorous activity. What they found is, over the course of the study, of course, physical activity that was higher-intensity improved cardiovascular fitness but wasn't as important as light activity in reducing truncal fat. You go, "How can that happen?" Well, these researchers basically showed that time spent in light activity -- again, I'll define light again here in a minute, about three to three and a half calories per minute, but they do it for much longer periods of time over the course of the day so the total energy expenditure in light intensity activity is far greater than what it would be if they only did moderate or vigorous activity for 50 or 60 minutes a day and then very little if anything the rest of the day. That's really what comes down to. And they found

that light activity is more tied to reducing abdominal and truncal fat and improving insulin sensitization over the course of a full day.

So the formal definition now of what we call “light activity” would be less than three METs or less than three and half calories per minute. For moderate activity, it would be less than three to six METs or three and a half to seven calories per minute. And vigorous activities is now defined is more than seven calories per minute or above six METs. That’s essentially if you ask what is the formal definition of “light.”

So yes, light doesn’t burn incredible numbers of calories. But if someone is doing light housework over the course of the day, look at the differences. If they’re doing light housework, one to three METs for five and a half hours per day, and you multiply that on the upper end at three and a half calories per minute, that’s 700 to 1,100 calories per day they would not have done otherwise had they just laid around and watched TV. Versus they go to a spinning class and work for 45 to 50 minutes, 400 to 500 calories at six-plus METs and do very little the rest of the day.

So keep in mind we do need to give value to those patients or clients who don’t work out from the fitness perspective but are active at two to three METs over the course of the seven-day week. That’s something most of us don’t give too much credence to, but we’re starting to see the value of this. Especially for those patients who are not probably going to engage in anything more than light activity any way, we still need to give them credit.

Again, what counts is light activity, gentle housework like gardening, shopping, walking less than three miles an hour, working at the computer. I’d have to say I’m not sure -- I’ve energy expenditure studies on working at a computer, and it’s depending on how anxious you are and your level of anxiety, working at your computer is generally about one and half to two METs, again, depending on the cognitive work as well as the computer work. So, again, we incentivize providers to record activities of daily living even though they may be classified as light.

As I said earlier in the introduction, I want to make really sure that we know the differences between physical activity and fitness, especially cardiovascular or aerobic exercise. They do overlap. Fitness is a trait, activity is a behavior. How do you use fitness and physical activity measures when reporting out in terms of educating your patients?

Physical activity is measured of course, as we talked about, as step counts, pedometry, estimating energy expenditure depending on how much time and the level of work that they’re doing. And of course, self-report right now, I think that’s what DDTP providers do. You self-report physical activity. “Did you get 150 minutes per week? More than 150 minutes? Less? Okay, that’s the best we can do in many cases, but I’ve got an answer to improving upon that.” The gold standard is doubly-labeled water. It’s a laboratory method that you can measure and get an accurate energy expenditure of physical activity over the course of the day. It’s a very expensive laboratory measure. We won’t talk about it, but you’ll see that in the literature quite a bit.

Whereas aerobic capacity, which is synonymous with cardiorespiratory fitness, is at least half determined got nothing to do with physical activity. And we’ve seen the human genome study report this. We know half of your physical activity determines -- your aerobic capacity or your Max VO2 is determined by how you pick your parents. And exercise intensity, if you’re working out. And gender. And it diminishes, a little bit with age, of course your aerobic capacity.

This is important to realize, I think. I mean if you look just at fitness or max aerobic capacity, keep in mind what max aerobic capacity includes. When you measure max aerobic capacity, you’re measuring three things; your heart’s ability to pump blood per minute; the size of the left ventricular chamber for each pump, each heartbeat; and the extraction of oxygen in the periphery. So it’s not just good enough to put out the blood and oxygen. You have to have enough mitochondria in the muscle to extract it. All

three are fitness-related. You could enhance all three by working out, but the biggest determinant of improving max aerobic capacity is higher-intensity aerobic exercise.

What I mean about higher, we're talking about generally above 60% of max VO2. But we now know genetics and training both determine max aerobic capacity. The Human Genome Project, Claude Bouchard who headed it up years ago, many papers on this. We know the genetics response varies. It does by age, sex, and baseline aerobic capacity within the range of 45% to 50%. That means your aerobic power or your aerobic capacity is at least half determined by genetics. Not true with physical activity. This is a behavioral trait. And that's I think what we really want to prioritize, in the IHS.

The longest running study called the "CARDIA Study." Many, many papers. Just look "CARDIA" up on Google, and wham, you've got 50, 60, 70 studies. It's a long 25-year study starting with young adults going through their life span. It's in its 28th year now. Yes, what they did find in the CARDIA study based on the paper just published, one of the many, we found that cardiorespiratory fitness and max VO2 is associated with the lower risk of developing pre-diabetes and diabetes, even when adjusting for their body weight and BMI over a 25-year time period. So we're not saying don't measure fitness and that it's not important. But what we're saying is it's still very predictive, including of diabetes and coronary disease. However, there's a strong genetic component. And if you don't measure fitness, you can also preferentially, this we'll talk about, measure physical activity.

Here is a paper. And Joanne Manson has shown this many times in her many presentations since 1992. Just saying, "How many times per week do you work out greater than 60% of max effort or vigorously?" As you workout, there's very little difference between two, three, or four vigorous exercise sessions per week and five in terms of lowering your risk of diabetes. So at least every other day in terms of predicting diabetes, working out vigorously. So there is a case to be made for working out more intensively, if the patient can do it and it's safe, no question about it. However, when you look at all the data for all-cause mortality, Jonathan Myers and Vic Froelicher in 2004, this data has been shown so many times but it still holds true, if you measure the cardiovascular fitness, cardiorespiratory fitness like the max VO2, we know that patients that have a six-MET capacity to walk or run on the treadmill versus those who have less than six-MET capacity have a much longer survival of all causes of death. We also know that those patients who generate 1,500 of 2,000 calories of exercise per week, 35,000 to 70,000 steps per week or whatever, more than very little or no activity, also have just as much reduction in all-cause mortality. So both have weight in predicting all-cause mortality. You can use both but you don't have to use both in terms of your measures for reporting this.

Now, I'm going to give you a hint. Because the 2018 guidelines -- and this is going to drive some of the recommendations for IHS. In two years, you will see the 2018 Physical Activity Guidelines Advisory for Americans of All Ethnicity out of the Office of Disease Prevention and Health Promotion. That committee -- I'm sorry, Melanie, I just didn't have time to look at this thing right up here -- this Advisory has now met three times. And right now, what they're going to be recommending in two years is 180 minutes of exercise per week. That's a bit more than the 150 now, right? That's where they're leaning because that has the sharpest reduction in all-cause mortality, especially the risk of dying prematurely of anything. So if you go from 30 minutes per week of moderate or vigorous exercise to 90 minutes a week to 180, you can see the risk is reduced by a pretty good 20% here and almost 27% here. And that looks like that's going to be the new recommendation.

Yes, if you exercise for 30 minutes per week, or only 20 minutes per week, you don't take your risk in half, but it gets pretty close. Remember, this is just number of minutes of physical activity, whether it be gardening or taking a step class or jogging or whatever. Keep in mind the definition of "moderate" is 40% to 60%, "vigorous" is above 60% of max effort.

So the bottom line, as I said, I think what we would prefer for outcomes reporting measures is physical activity. Just move and move often. And you know that statement well from my previous -- for those of you who have heard my webinars, just move. But somehow we've got to measure this. Self-report is

one way. Pedometry is another way. We can also use intensity. It's a secondary measure. Intensity that is just move, but half of your movement per week should be at least 50% to 60% or greater of effort level. You get benefit from that, but there's risk with increasing intensity, especially with patients with known metabolic issues.

I'm going to skip that slide for the moment and say that most of you, not all of you, live in environments of what I call "Native lands" where you have multiple terrain; yes, you have weather conditions, et cetera, early nightfall; but in some cases, hot summers and very cold winters. But the good news that we don't have in mini cities is a variable outdoor terrain with full-spectrum sunlight. Really, for most of you, you do have the environment to get most of this done with wonderful outdoor trails and meteorologic conditions -- or I should say geologic conditions -- where if you have multiple terrain, you burn more calories.

Julie asked, "Do you recommend running, or you feel it is bad for the joints?" I just had my right knee replaced. And I went to college on a track scholarship. Does that mean my right knee arthritis is running related? Probably not. We don't think it's overused -- early osteoarthritis, rather. But I can't run anymore. So I hate to say it's only bad for the joints if you have premature or active osteoarthritis of weight-bearing joints. I would rather someone walk and increase caloric expenditure of walking at stairs or multiple terrain. And you'd get just about as much as you would have with walking over a variable terrain variable as you would running.

In the IHS, the realities of assessing physical activity, I know you know the required key measures that you have to report as your outcomes measures, of course. I'm not really sure of your evaluation tools. I've looked all over the internet. I must have missed them, I think it's self-report, above 150 minutes per week, below 150 minutes, self-report activity in terms of evaluation of actual physical activity. Your "Just Move It!" perhaps there's some more. But I do know your current website at DDTP does very clearly ask for physical activity measures, measures of physical activity and fitness levels.

I'm going to list some standard fitness tests. And most of you may already use your own standard test of a mile walk for time or shallow runs or whatever else. Or certainly for resistance exercise, one RM max. There are even yoga tests that you can do for musculoskeletal resistance fitness, there's no question about it. I'm not sure what you use there, I'd like to see how you report fitness levels, muscular fitness or aerobic fitness.

On physical activity, I already pretty much know what you do. It's usually self-report as far as I can tell. I also know you're giving additional options. You can write in your own measures. And that's where I would recommend pedometry. Clinical pedometry, that book chapters and you have on your Quick Guide Cards on the IHS DDTP website, it's still quite valid, standard pedometry measures. Notwithstanding the patient can make errors in reading the pedometer and losing the pedometer. But it's some more cost-efficient than using other self-report measures in terms of being reliable tools to measure 24 hours of physical activity or seven days or thirty days or ninety days of physical activity. You can write in your own measures, I know you have that capability.

When you look at actual reported measures of fitness tests, cardiorespiratory fitness, you all know these. Some of these tests are sub-maximal testing, you extrapolate what the maximum rate would be if you go beyond 80%, of course. The Mile Rockport test is still very popular. It's the kind that takes you to walk a measured mile around a track or a measured mile -- what the workload is on a stationary bike when in your heart rate reaches 170, some people still use that. I would not recommend the bench step test anymore, but it still is used in some instances.

I would sure like to know which ones you use, if in fact you do use as an outcomes measure before, during, and after physical activity programming, fitness changes. What I would really like to see is the use of pedometers. Accelerometers are far more expensive. Accelerometers measuring steps and pedometers measuring steps have the same validity overall. Accelerometers are better at estimating

energy expenditure and even distance to some degree. But we already know, even with accelerometry, there's a great error underestimating and some cases overestimating energy expenditure with these wrist- or waist-worn devices. I would stick with pedometers. They're far cheaper and less expensive when you lose them. They are self-report and the RAPA is starting to go out of style because it's been misinterpreted by patients. It's difficult to understand for many patients, the RAPA activity physical assessment of several, about 10 questions.

The PA Vital Signs by Exercise is Medicine; if you Google Exercise is Medicine, it is probably the most popular clinical website for incentivizing medical providers, especially physicians, on promoting physical activity, even light physical activity.

Diaries/logs, self-report as we've already talked about, I'd like to see pedometry where the pedometer is prescribed, given instructions, it's written out on a script form, and the script form looks like identical to a medication prescription. Same size, two-ply, one ply goes to the chart and one ply goes to the patient. And that's followed, the patient doesn't reset that until the end of the week and records that and then brings that log back to you. At least for the first three months. That has worked quite well. Long-term pedometers, there is a fall-off in compliance, of course, I'm sure you realize.

And I will say this. If you want, and this was published three years ago, it's the single authority long paper on the scientific advisory, on every single method to measure physical activity, including the ones I just mentioned in the previous slide. And if you go to Circulation November 12, 2003, or just Google that, Google the title of this, you can download. I think it's 50 pages long. Every single valid measure of measuring physical activity and their ranking is on this paper. That's a very important paper. But mostly IHS DDPT purposes, I still pedometry is at long-term going to be your best bet. This are just a couple of charge charts that, this strings, et cetera.

The very last thing I'm going to say very quickly is, predicting energy cost of activity, since most of the all-cause mortality studies using physical activity and doing 100 calories per week or 1,500 calories per week is based on the provider's ability to predict energy expenditure, as we already told you, steps relate to energy expenditure. Every mile a patient walks for the most part is worth about a hundred gross calories. The heavier patients burn up to 140 calories per mile. But calories expended, the reason steps can be transduced to calories is because calories also relate to the number of muscle contractions. And vice versa the number of muscle contractions also relate to caloric expenditure.

Energy cost of physical activity, if you're going to estimate it, you're going to know how much time they spent, the relative intensity, what they we're doing and their body weight. How do you that? This has stood the test of time. Roughly 30 minutes of sustained moderate physical activity is worth about 300 calories. For those that are BMI 35 to 40 or heavier, it's probably closer to 400. Especially with weight-bearing exercise. But overall, for you or I or most of your patients, half an hour of moderate exercise is about 300 calories.

Cameron Hall from Syracuse and Katherine Hall from Duke University have the two similar papers on predicting physical activity energy expenditure. What you need to know, again, I'm not talking about fitness trackers now, I'm just saying just think about this. This was Katherine Hall's paper. If you walk a mile -- and what she did, she have several hundred patients walk a mile -- and then do a measure of energy expenditure for that mile, look at the spread. Some patients' relative energy expenditure and calories per minute walking that mile, they average two to three calories per minute. Some of the heavier patients were burning 10 to 12 calories per minute. It in the middle, that five or six calories per minute, moderate patients are about where the average is. But just know the point here is there is a real spread about how many calories three different, two different, ten different patients expend per mile. But we will say this. The heavier the patient is, the good news there is for any given pace, even a slow pace, they're going to burn more total calories per mile.

Now, the net versus gross expenditure. I've said this before in a webinar about four years ago. You have a patient that says, "I'm going now for a one mile walk this afternoon. I'm going to break away from the PC. I'm going out for a one mile walk." And what I'm going to do, I didn't walk that one mile, I would have spent 20 minutes at the desk in my PC entering data, for example. But instead I walk a 20-minute mile instead of that desk job, right? They go out for a 20-minute walk. And it's true. A 20-minute walk at three miles per hour for the vast majority of us is about 80 to 90 calories. The difference between the two is the net. The difference between the two, and it's true to this day, is when someone walks five miles on a treadmill, the treadmill reports gross energy expenditure and not net. The net is what you actually expended beyond what you would have done anyway had you not chosen to walk that 20 minutes on the treadmill. That's the net.

I don't think you need to tell the patient all this, but it's one reason why people don't lose the weight that they think they should lose based on what a treadmill or a cycle or a rowing machine reads out on the display. The display reports twice this amount, especially for walking. It's the gross energy expenditure. So just know the difference between the two, what you would have done anyway versus which you actually did during that 20 or 30 to 40 minutes is really what is important when looking at total energy expenditure. So at moderate walking speeds, the net energy cost for walking one mile is about 60% of the gross cost or 50 to 60 calories per mile. It may be a little bit more for some who is very heavy.

So these are the equations. If you're walking two to four miles per hour, this is the gross cost for mile. If you're BMI is less than 30, it's 100 calories. If your BMI is greater than 30, 140. The net cost, the important difference, as we said, is the net cost is the actual added calories you spend during that session walking three to four miles. So if your BMI is less than 30, about 55 calories per minute. If your BMI is greater than 30, about 60 to 90 calories or even more per minute.

And finally, and this is something that you're not going to be able to calculate but is the biggest single contaminant for exercise-generated weight loss research. Energy compensation that is the increased food intake as the result of appetite suppression. About a third to maybe a little bit more than a third of us actually increase and eat an extra scone or whatever after a day when we exercised for one hour. Versus many of us, about a third or maybe more actually decrease spontaneous physical activity as a result of the decreased energy within the two or three hours after a moderate to vigorous workout. That would not have been decreased had we had not worked out.

I mean just think about it, if you go out and walk eight miles, what are you going to do for the next two hours after the eight miles? Something less than you would have done anyway. So it's just something to keep in mind. So the bottom line to this day is how much weekly physical activity is required for weight loss in most obese patients. At least fifteen hundred, but more generally, over 2,000 calories of exercise a week, and probably close to 3,000 calories of exercise per week. That translates for most patients with a BMI around 32 to 35, that 1,500 means 12 miles of walking or more per week; at the top end, 22 to 25 miles per week. You can see that's quite an investment of time.

The last thing, I just want to say, yes, if you do multiple sets of resistance exercise, obviously you burn more calories. This is one of many studies that show if you're doing three sets workout of five or six exercises, you're going to burn a lot more than a single set in terms of the gross cost, not at the net cost. So the more sets, the more reps, the more energy expenditure.

Here's another study from Brazil which I thought was excellent. Magosso and others showed that, let's say you do three to five sets of 10 repetitions each. This is incorrect, forget this. You do actually three to five sets of 10 repetitions each. The first set, you burn about 10 count calories, this is if you're bench press or leg press. The second set, you burn 11 calories for that set. Each successive set burns more calories. So what we're saying is, let say four sets of a given exercise like bench press or leg press is worth about 50 calories, okay? Each successive set burns about 10% to 12% more calories. So about 50 calories. But to compare, a one mile walk is about 100 gross calories or about 60 net calories. This

would be probably closer to 30 net calories. You're still better off with not a shuffle, but at least a moderate paced one mile walk in terms of actual energy expenditure. Of course, these people are going to get stronger and have greater levels of musculoskeletal -- so I'm just talking about burned calories here.

Yoga, in general, yoga and almost all forms asanas and yoga sessions, you only expend about three METs of activity. You have other benefits that are utterly important. But in terms of caloric expenditure, it's not very much. With one exception, the famous sun salutation. If you do the sun salutation, which is built into many yoga sessions, it's about close to eight METs. The sun salutation is series of 12 asanas, and you repeat that often, three cycles of these. And I can tell you, now you're talking about the equivalent of at least moderate-level aerobic exercise. It's one of the first studies that actually did show advanced energy expenditure with yoga.

At that, because of the time, I'm going to finish up here and just say in a very, very brief summary that we would like to see most of you measure physical activity in some direct way other than just or in addition to self-report.

Keep in mind, fitness tests are still good, but they don't relate as much to long-term disease risk or mortality. At least resistance or musculoskeletal fitness tests don't. But for other reasons, they're important. Using fitness activity trackers, as you know, what we meant and what we said, for all of you, we really would like you to just determine the number of steps over the course of the day and discard the energy expenditure. And even the distance on these physical activity trackers are more important to measure from a clinical perspective.

Let me just answer one question. We only have about four or five minutes left. Any study showing specific impact or the amount of the percent increase in insulin sensitivity for minutes of the activity, like 30 minutes of exercise equals a particular increase in effectiveness of insulin sensitization? Yes. Many do, but not in those terms. What they relate the number of minutes -- instead of using the number of minutes, they use energy expenditure or percentage of max effort, which do relate to insulin sensitivity. We do know that 30 minutes of low level walking, moderate to low level walking increases insulin sensitization. But we also know that 30 minutes of faster-paced walking is a greater insulin sensitizer. So both a low pace and fast pace walking increase insulin sensitization. We also know that the more reps and the more sets you do, the more insulin sensitization you also gain from resistance training.