UNIVERSIDADE FEDERAL DE PERNAMBUCO
CENTRO DE CIÊNCIAS BIOLÓGICAS
PROGRAMA DE PÓS-GRADUAÇÃO EM BIOQUÍMICA E FISIOLOGIA

TESE DE DOUTORADO

DIABETES TIPO 2 EM IDOSOS SEDENTÁRIOS: ASPECTOS EMOCIONAIS, FUNCIONAIS E METABÓLICOS

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RECIFE, 2012

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Tese apresentada para o cumprimento parcial das exigências para a obtenção do título de Doutor em Bioquímica e Fisiologia pela Universidade Federal de Pernambuco

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Data: 28/12/2012

Catalogação na Fonte:
Bibliotecário Bruno Márcio Gouveia, CRB-4/1788

F547d Fittipaldi, Etiene Oliveira da Silva

Diabetes tipo 2 em idosos sedentários: aspectos emocionais, funcionais e metabólicos / Etiene Oliveira da Silva Fittipaldi. – Recife: O Autor, 2012.

145 folhas: tab.
Orientadora: Maria Teresa Jansem de Almeida Catanho
Coorientadora: Armèle Dornelas de Andrade
Tese (doutorado) – Universidade Federal de Pernambuco. Centro de Ciências Biológicas. Pós-graduação em Bioquímica e Fisiologia, 2012.

Inclui referências

1. Diabéticos 2. Diabetes - Aspectos nutricionais 3. Aptidão física I. Catanho, Maria Teresa Jansem de Almeida (orientadora) II. Andrade, Armèle Dornelas de Andrade (coorientadora) III. Título.

616.462 *CDD (22.ed.)* *UFPE/CCB-2013-033*

AGRADECIMENTOS

À minha orientadora, Profa. Dra. Maria Teresa Jansem de Almeida Catanho por ter me acolhido e me proporcionado a realização de mais um sonho. Minha admiração e meu respeito.

À minha co-orientadora e amiga, Profa. Dra. Armèle Dornelas de Andrade, por ter me apoiado sempre e verdadeiramente ao longo dessa caminhada. É com muita emoção que a agradeço.

A todos os idosos que não mediram esforços para colaborar com esse estudo, a minha infinita gratidão.

Ao Núcleo de Atenção ao Idoso (NAI/UFPE), representado pelas minhas amigas, Ana Paula de Oliveira Marques e Márcia Carrera Leal, pelos valiosos incentivos ao aprimoramento dos saberes na área da Gerontologia.

Ao Núcleo de Articulação e Atenção Integral à Saúde e Cidadania da pessoa Idosa (NAISCI/UPE), principalmente a Sálvea Campelo e a Tatiana Carvalho, amigas que me acompanham na caminhada da Gerontologia.

À equipe que compõe o PSF Macaxeira / Burity (Prefeitura do Recife), em especial à Dra. Maria de Fátima Maciel e à ACS Maria Salomé de Lucena, agradeço pela eficiência e disponibilidade.

Às fisioterapeutas, Daniella Brandão, Helga Muniz, Luciana Alcoforado e Maíra Pessoa, à cardiologista Dra. Maria Inês Remígio e a toda a equipe do Laboratório de Fisioterapia Cardiopulmonar (UFPE), pelas relevantes contribuições.

A Shirley Lima Campos, minha mais nova amiga e companheira de estudos, a quem eu devo muito carinho pelo empenho em partilhar conhecimentos, pela preciosa ajuda em tão curto espaço de tempo.

Às minhas alunas, Ada Salvetti, Ana Karolina Pontes, Bruna Azevedo, Dilza Cavalcante, Maria Menezes, Paula Barros e Waléria Silveira que tanto me ajudaram e ensinaram.

Ao Laboratório de Análises Clínicas do CISAM (UPE), em especial, a José Gomes, pelo alto grau de compromisso e dedicação.

Às colegas do doutorado, Helane e Mônica, que, inegavelmente, sem o estímulo de vocês, não teria ultrapassado as *fronteiras*... necessárias para chegar ao topo final.

Aos colegas dos Mestrados de Bioquímica e Fisiologia e de Fisioterapia, pelos momentos de grandes vivências nas disciplinas. Imensas saudades.

A Ana Célia Oliveira por toda a ajuda, disponibilidade e carinho. Você é mais um presente especial em minha vida.

A Solange Pessini Siepierski, pela atenção, pelo carinho e por tanta dedicação e colaboração "*indispensable*" nas horas mais difíceis dessa minha trajetória.

Às minhas amigas e irmãs, Ângela Lobo, Consuelo Figueira, Maria Luiza Menezes e Vera Lúcia Gomes, por terem surgido e permanecido em minha vida, mesmo que, nesses últimos quatro anos, o convívio tenha ficado um pouco escasso.

Aos meus familiares que se foram ao longo desses quatro anos, Papai, tia Mima, tia Dadá, tio Paulo, tio Antônio, tia Vadinha e Dejanira, pelas bênçãos enviadas. Sei que onde estiverem zelam por mim.

A todos os que participaram, de forma direta ou indireta da realização de mais um sonho, agora tornado realidade.

A Deus, por ter sempre me mostrado o caminho da fé quando tudo parecia impossível.

RESUMO

INTRODUÇÃO: Diabetes Mellitus tipo 2 (DM2) em idosos vem sendo associado à presença de transtornos emocionais, alterações no estado nutricional, redução da capacidade funcional e aumento dos riscos cardiovasculares e metabólicos. Concomitantemente, a presença desses fatores e do comportamento sedentário favorece a redução do desempenho cardiorrespiratório, interferindo na independência desse idoso ao realizar suas atividades cotidianas. Deve-se salientar que, embora a atividade física regular venha sendo um dos principais eixos do programa de tratamento não farmacológico do DM2, qualquer tipo de exercício não deve ser iniciado antes de uma avaliação criteriosa do estado geral desse idoso, principalmente na presença de outra doença crônica, comumente associada ao diabetes, a hipertensão arterial sistêmica. Como parte dessa avaliação, incluem-se o estado nutricional e emocional, os exames laboratoriais, a expressão dos índices de avaliação funcional e o teste ergoespirométrico para avaliação do desempenho cardiorrespiratório. **OBJETIVOS:** Para designar as relações entre DM2 em idosos e sedentarismo quanto aos aspectos emocionais, funcionais e metabólicos, foram conduzidos três estudos: (I) Estudo transversal, com o objetivo de analisar a interação de declínio funcional, dislipidemia e redução da atividade física como preditora de sintomas depressivos em 85 idosos diabéticos; (II) Estudo transversal, para descrever a influência do DM2 no desempenho cardiorrespiratório de hipertensos e diabéticos, realizado em 40 idosos sedentários e (III) Ensaio paralelo, para comparar os efeitos da execução do teste ergoespirométrico sobre as variáveis lipídicas de indivíduos sedentários com hipertensão arterial e com hipertensão arterial associada ao diabetes mellitus tipo 2 em 20 idosos hipertensos e 20 hipertensos e diabéticos. **MÉTODOS**: Foram avaliados sujeitos de ambos os gêneros, com idade igual ou superior a 60 anos. Para todos os estudos, foram realizadas avaliações do estado nutricional (Índice de Massa Corporal), pressão arterial sistólica e diastólica (PAD e PAS), autonomia funcional (Índice de Lawton e Brody), nível de atividade física (*International Physical Activity Questionnaire*) e determinações bioquímicas (Glicose, Triglicerídeos, Colesterol total e suas frações, colesterol de baixa densidade_LDL-C, de muito baixa densidade_VLDL-C e alta densidade_HDL-C). Apenas para o estudo (I), foram avaliados os sintomas depressivos (*Yesavage Geriatric Depression Scale*) e o desempenho cardiorrespiratório (variáveis do teste ergoespirométrico: consumo de oxigênio de pico_VO_{2pico}, tempo para atingir o VO_{2pico}, produção de gás carbônico_VCO_2 e equivalente ventilatório do gás carbônico_VE/VCO_2) fez parte da avaliação nos estudos (II) e (III). A análise dos dados foi processada utilizando-se o aplicativo *Statistical Package for the Social Sciences* (SPSS), versão 15.0. Todos os testes foram aplicados com 95% de confiança. Em todos os estudos, foi utilizado o Teste de Normalidade de Kolmogorov-Smirnov. Para associações intergrupos, aplicou-se o Teste Mann-Whitney e intragrupos, o Teste Wilcoxon. Os estudos das correlações foram conduzidos pelo teste não paramétrico de Spearman assim como as Regressões Lineares Múltiplas, com análise de variância, foram realizadas para testar preditores de determinados desfechos. **RESULTADOS:** De acordo com os estudos conduzidos, os principais resultados foram: os sintomas depressivos foram correlacionados significativamente com o declínio funcional, a dislipidemia e a redução da atividade física, os quais foram preditores dos sintomas depressivos (estudo I); o DM2, quando associado à hipertensão e ao sedentarismo, produziu menor eficiência cardiorrespiratória que teve como principal preditora a pressão arterial diastólica (PAD) (estudo II), e idosos hipertensos e diabéticos apresentaram pior desempenho cardiorrespiratório, ocorrendo uma relação linear do tempo para atingir o VO_{2pico} com os níveis de LDL-C, assim como a relação entre VE/VCO_2 com as concentrações plasmáticas de TG e as frações de colesterol, VLDL-C e HDL-C (estudo III). **CONCLUSÕES**: Diante dos principais achados, foram elaborados três artigos que permitem concluir que a associação de declínio funcional, dislipidemia e redução da atividade física favorece a presença de sintomas depressivos nos idosos diabéticos. Mas, dentre todos os fatores estudados, os mais altos níveis de PAD e LDL-C assim como os mais baixos de HDL-C demonstraram ser preditores do pior desempenho cardiorrespiratório em idosos diabéticos e hipertensos, fortalecendo, ainda mais, a continuidade no sedentarismo. Novas estratégias para incentivar a prática da atividade física regular, a partir de intensidades leve e moderada, podem prevenir o surgimento dos sintomas depressivos, retardar a progressão do declínio funcional, controlar a dislipidemia e melhorar a capacidade cardiorrespiratória dessa população.

Palavras-chaves: Diabetes Mellitus tipo 2; Hipertensão; Idoso; Sintomas Depressivos; Dislipidemias; Condicionamento Físico; Estilo de Vida Sedentário.

ABSTRACT

INTRODUCTION: Type 2 Diabetes Mellitus (T2DM) in the elderly has been associated with emotional disorders, changes in nutritional status, reduced functional capacity and increased cardiovascular and metabolic risks. Concomitantly, the presence of these factors together with sedentary behavior favors the reduction of cardiorespiratory performance, interfering with the elderly independence in performing their daily activities. It should be noted that although regular physical activity is one of the main axes of the T2DM non-pharmacological treatment program, no exercise should be done before a careful evaluation of the elderly general state, especially in the presence of hypertension, another chronic disease commonly associated with diabetes. This evaluation includes emotional and nutritional status, laboratory tests, functional assessment indices, and ergospirometric test to assess cardiorespiratory performance. **OBJECTIVES:** To describe the relationship between T2DM and sedentariness in older adults with respect to the emotional, functional and metabolic aspects were used three studies: (I) Cross-sectional study aiming to analyze the interaction of functional decline, dyslipidemia, and reduced physical activity as a predictor of depressive symptoms in 85 diabetic elderly subjects; (II) Cross-sectional study to describe the influence of T2DM in the cardiorespiratory performance of the hypertensive, diabetic, sedentary elderly, conducted in a sample of 40 subjects; and (III) Parallel trial to assess the effects of the execution of the ergospirometric test over the lipid variables of sedentary individuals with hypertension and hypertension associated with type 2 diabetes mellitus in 20 hypertensive elderly and 20 hypertensive diabetic elderly. **METHODS**: Were evaluated male and female subjects, aged 60 or above. All three studies assessed nutritional status (body mass index), systolic and diastolic blood pressure (SBP and DBP), functional autonomy (Lawton and Brody Index), physical activity (*International Physical Activity Questionnaire*) and biochemical determinations (glucose, triglycerides_TG, total cholesterol and its fractions, low density_LDL-C, very low density_VLDL-C and high density_HDL-C). Study (I), only, analyzed depressive symptoms (*Yesavage Geriatric Depression Scale*). Cardiorespiratory performance (ergospirometric test variables: peak oxygen consumption_VO_{2peak}, time to reach VO_{2peak}, carbon dioxide production_VCO_2 and ventilatory equivalent carbon dioxide VE/VCO_2 was part of studies (II) and (III). Data analysis was processed by Statistical Package for Social

Sciences (SPSS), version 15.0. All tests were applied with 95% confidence. The Kolmogorov-Smirnov Normality Test was used in all studies. For intergroup associations, it was applied the Mann-Whitney test and for intragroup, the Wilcoxon test. The Correlation Studies were conducted by the Spearman' nonparametric test. The Multiple Linear Regressions, with variance analysis, were conducted to test predictors of certain outcomes. **RESULTS:** According to the studies performed, the main results were the following: the depressive symptoms were significantly correlated with functional decline, dyslipidemia, and reduced physical activity, which were predictors of the depressive symptoms (study I); 2TDM, when associated with hypertension and sedentariness, led to lower cardiorespiratory efficiency, which main predictor was the diastolic blood pressure (DBP) (study II). The diabetic hypertensive elderly had a poorer cardiorespiratory performance. It was observed a linear relationship between the time to reach VO_{2peak} and LDL-C, as well as the relationship between VE/VCO_2 and plasma concentrations of TG and cholesterol fractions, VLDL-C and HDL-C (study III). **CONCLUSIONS:** Based on the main findings, three articles were written showing that the association of functional decline, dyslipidemia, and reduced physical activity favors the presence of depressive symptoms in the diabetic elderly. But among all the studied factors, the higher levels of DBP and LDL-C, as well as the lower levels of HDL-C, proved to be the predictors of the low cardiorespiratory performance in the diabetic hypertensive elderly, favoring even more the prevalence of sedentariness. New strategies to encourage mild to moderate regular physical activity may prevent the onset of depressive symptoms, slow the progression of functional decline, control dyslipidemia and improve cardiorespiratory capacity in this population.

Keywords: Diabetes Mellitus, Type 2; Hypertension; Aged; Depressive Symptoms; Dyslipidemias; Physical Fitness; Sedentary Lifestyle.

LISTA DE ABREVIATURAS

ACSM	American College of Sports Medicine
AF	Atividade Física
AIVD	Atividades Instrumentais da Vida Diária
AVD	Atividades da Vida Diária
CC	Circunferência da Cintura
CF	Capacidade Funcional
CT	Colesterol Total
DCNT	Doenças Crônicas Não Transmissíveis
DCR	Desempenho Cardiorrespiratório
DCV	Doenças Cardiovasculares
DM	Diabetes Mellitus
DM1	Diabetes Mellitus tipo 1
DM2	Diabetes Mellitus tipo 2
HAS	Hipertensão Arterial Sistêmica
HDL-C	Lipoproteína de alta densidade – colesterol
IMC	Índice de Massa Corporal
LDL-C	Lipoproteína de baixa densidade – colesterol
OMS	Organização Mundial de Saúde
PAD	Pressão Arterial Diastólica
SD	Sintomas Depressivos
TG	Triglicerídeos
VCO_2	Produção de gás carbônico
VE/VCO_2	Equivalente ventilatório do gás carbônico
VE/VO_2	Equivalente ventilatório do oxigênio
VO_2	Consumo de oxigênio
VO_{2max}	Consumo máximo de oxigênio
VO_{2pico}	Maior valor de oxigênio alcançado no final do exercício

SUMÁRIO

1. INTRODUÇÃO

O aumento da proporção de idosos na população é um fenômeno universal, cujo crescimento anual no século XXI vem ocorrendo continuamente (CARVALHO, RODRÍGUEZ-WONG, 2008). Segundo a Organização Mundial de Saúde (OMS), a população acima dos 60 anos de idade vem crescendo em ritmo acelerado, devido a fatores, como o aumento da expectativa de vida e a diminuição das taxas de natalidade (OMS, 2010).

No Brasil, o Censo demográfico, realizado em 2010, revelou, a partir da pirâmide etária, que aproximadamente 10% da população brasileira encontram-se na faixa etária acima dos 60 anos, sendo esse o limite de idade entre o indivíduo adulto e o idoso para as nações em desenvolvimento (IBGE, 2010).

Essa transição demográfica é um dos mais urgentes problemas mundiais. Os cenários de seguridade e sistemas de saúde são assustadores. Ao contrário dos países desenvolvidos, que se tornaram ricos antes de envelhecer, os países em desenvolvimento estão envelhecendo antes de enriquecerem. Esse fato traz um imenso desafio para os países em desenvolvimento em muitas áreas, principalmente na saúde (KALACHE, 2008).

O envelhecimento da população vem transformando o perfil de saúde dos países em desenvolvimento. O Brasil, em menos de 40 anos, passou de um perfil de mortalidade materno-infantil para um perfil de mortalidade por enfermidades mais complexas e mais onerosas, típicas das faixas etárias mais avançadas, nas quais predominam as Doenças Crônicas Não Transmissíveis (DCNT) e suas complicações (ALVES *et al.,* 2007).

A cada ano, 650 mil novos idosos são incorporados à população brasileira, a maior parte com DCNT e limitações funcionais incapacitantes, que perduram por anos, exigindo cuidados constantes, medicação contínua, exames periódicos e uma maior procura dos idosos por serviços de saúde (VERAS, 2009).

2. FUNDAMENTAÇÃO TEÓRICA

2.1. Diabetes e Envelhecimento

O Diabetes Mellitus (DM) é um exemplo de DCNT, que aumenta com o avançar da idade, tornando-se um dos maiores problemas de saúde pública do século atual. Este se refere a um espectro de síndromes de distúrbio metabólico, as quais são caracterizadas pelo elevado nível de glicose no sangue (ADA, 2011).

A prevalência do DM está aumentada em todo o mundo, em adultos de todas as idades (WEI *et al.,* 2002). Nos países ocidentais, é estimada em 6% a 7,6%. Entre os anos de 1995 e 2025, acontecerá um aumento de 35% em nível mundial, e o número de pessoas portadoras da doença será superior a 300 milhões, configurando uma verdadeira epidemia (KING *et al.,* 1998).

O DM representa um grupo de doenças metabólicas que se caracterizam por hiperglicemia, frequentemente acompanhada de dislipidemia, hipertensão arterial e disfunção endotelial. As consequências, em longo prazo, dessa doença resultam de alterações micro e macrovasculares, que podem levar à disfunção de vários órgãos, como olhos, rins, nervos, coração e vasos sanguíneos (ADA, 2009; ADA, 2011).

As complicações crônicas, tais como: retinopatia, nefropatia, neuropatia periférica, neuropatia autonômica e doenças aterotrombóticas, diminuem a qualidade de vida das pessoas idosas, com grandes repercussões para suas famílias e ao desempenho das suas atividades laborais, aumentando, ainda, o custo econômico do Estado (ADA, 2009).

Estudos realizados no Brasil evidenciaram que, entre os sujeitos de 18 a 59 anos de idade, a prevalência da referida doença é de 2,3%, podendo atingir 17,3% entre aqueles com 60 anos ou mais (ZAGURY *et al.,* 2002; PASSOS *et al.,* 2005; MORAES *et al.,* 2010).

As duas principais apresentações em importância clínica e em prevalência são o DM tipo 1 (DM1) e o DM tipo 2 (DM2). Esse último é uma doença crônica, que afeta bastante a população idosa, definido como um grupo de desordens metabólicas, caracterizado por hiperglicemia resultante da deficiência na secreção ou na ação da insulina ou em ambas (INTERNATIONAL DIABETES FEDERATION, 2011).

Entre as diferentes classificações do diabetes, o DM2 é a de maior incidência, responsável por aproximadamente 90% dos casos (BARCELÓ, RAJPATHAK, 2001). A idade do aparecimento do DM2 é variável, embora seja mais frequente após os 40 anos de idade, sendo a maior incidência ao redor dos 60 anos. Com relação ao gênero, a incidência e a prevalência do DM2 é 1,4 a 1,8 vezes mais frequente nas mulheres do que nos homens (GOLDENBERG *et al.,* 2003).

Associando esses dados ao aumento da prevalência dessa enfermidade na população, a Organização Pan-Americana da Saúde estima que a maioria dos diabéticos, nos próximos anos, será constituída de mulheres idosas (OPAS, 2003).

O DM2 tem sido considerado doença do estilo de vida moderno nos países ocidentais, e sua incidência vem aumentando, rapidamente nos últimos anos, associada ao crescimento da condição de obesidade. Esses incrementos têm sido atribuídos ao sedentarismo e aos hábitos alimentares predominantes no estilo de vida atual (SUI *et al.,* 2007; LI *et al.,* 2011).

Resistência à insulina (RI), hiperglicemia, obesidade, dislipidemia, tabagismo e hipertensão são fatores de risco comuns para doença vascular em pessoas com diabetes, especificamente DM2 (CADE, 2008).

Ao lado da hipertensão arterial e do envelhecimento, o DM2 pode induzir alterações funcionais e estruturais das grandes artérias, e assim, levar ao desenvolvimento de aterosclerose e suas consequências cardiovasculares (BORTOLOTTO, 2007). Entretanto, intervenções intensivas no estilo de vida melhoram o controle do risco cardiometabólico, que se encontra aumentado nos diabéticos (LEITER, 2006).

A atividade física tem sido um dos principais eixos dos programas de prevenção e de tratamento do DM2, sendo altamente benéfica quando realizada antes e/ou durante a instalação da patologia (SIGAL *et al.,* 2006; COLBERG *et al.,* 2010).

Idosos diabéticos, que permanecem ativos fisicamente, têm um envelhecimento mais saudável em relação àqueles que não praticam atividade física. Dessa forma, os sedentários apresentam maior probabilidade de manifestar, com o passar dos anos, comorbidades associadas ao DM2 (NELSON *et al.,* 2007; RIBISL *et al.,* 2007), sendo a redução da capacidade aeróbica um grande fator de risco para o surgimento de limitações funcionais e cardiorrespiratórias (KWON *et al.,* 2011; LATIRI *et al.,* 2012).

Durante o processo de envelhecimento, todos os sistemas e órgãos sofrem algum tipo de declínio, e, quando associado ao DM2, as complicações se tornam mais evidentes, provocando transtornos emocionais, acarretando sintomas depressivos, principalmente altos níveis de depressão (WIN *et al.,* 2011), alterações no estado nutricional, caracterizadas pela presença de sobrepeso e obesidade (GOMES *et al.,* 2006), redução da capacidade funcional (SINCLAIR *et al.,* 2008; KALYANI *et al.,* 2010). Ainda, aumentam-se os riscos cardiovasculares e metabólicos (LI *et al.,* 2011), predominando um baixo desempenho cardiorrespiratório (REGENSTEINER *et al.,* 2009).

2.2. Transtornos Emocionais

Dentre os possíveis transtornos emocionais, que acometem o idoso, os sintomas depressivos (SD), considerados como precursores para depressão clínica (DALEY, 2008), são identificados como sintomas, que duram duas ou mais semanas com perda associada de prazer na realização das atividades habituais (McDOUGALL Jr. *et al.,* 2012). A presença desses sintomas tem sido significativamente maior em pacientes com DM2 (18%), comparando-se com aqueles sem a patologia (10%) (ALI *et al.,* 2006).

Os SD são uma condição clínica frequente em idosos, que vivem em comunidade, apresentando alta prevalência em diabéticos, principalmente do gênero feminino (CALHOUN *et al.,* 2010; PAN *et al.,* 2010). Esses sintomas relacionam-se a piores controles glicêmico (CHIU *et al.,* 2010; EGEDE, ELLIS, 2010) e lipídico (SHIN *et al.,* 2008; LEHTO *et al.,* 2010), com alterações no estado nutricional (HELD *et al.,* 2010), a uma pior saúde autopercebida (WEXLER *et al.,* 2012), a um aumento e a uma maior gravidade das complicações clínicas (SCHRAM *et al.,* 2009; BELL *et al.,* 2010), principalmente as cardíacas (KUPPER *et al.,* 2012).

Os altos níveis de depressão, que vêm sendo encontrados nos idosos com DM2 (WIN *et al.,* 2011), têm proporcionado menor convívio social e diminuição do desempenho do autocuidado, o que impede a adoção de comportamentos eficazes de autogestão, incluindo comportamento alimentar adequado, medidas de automonitoramento no controle da glicemia e atividade física (EGEDE, OSBORN, 2010; CONN *et al.,* 2010).

A presença de SD quase duplica a probabilidade de inatividade física nesses indivíduos (KOOPMANS *et al.,* 2009). Essa associação de sintomas depressivos com inatividade física favorece o surgimento da dependência funcional (ARAKI, ITO, 2009) e aumenta o risco de mortalidade cardiovascular nos idosos (WIN *et al.,* 2011).

2.3. Alterações no Estado Nutricional

A alta incidência do DM2 está associada ao crescimento da obesidade e vem sendo considerada doença do estilo de vida moderno nos países ocidentais e um crescente problema de saúde pública. Esses incrementos se atribuem ao sedentarismo e aos hábitos alimentares predominantes no estilo de vida atual (PEIXOTO *et al.,* 2007). O sobrepeso e a obesidade atingem 75% dos diabéticos nas diferentes regiões do Brasil, sendo o gênero feminino o mais acometido (GOMES *et al.,* 2006).

Durante o envelhecimento, ocorre redução do tecido muscular e aumento da adiposidade na musculatura esquelética e em outros tecidos (LANG *et al.,* 2010), consequentemente incremento da gordura corporal total. Além do aumento da gordura corporal, observa-se redistribuição desse tecido, havendo preferencialmente, na presença de doenças metabólicas, o acúmulo na região abdominal (WANNAMETHEE *et al.,* 2007; RYAN, 2010).

A identificação do Índice de Massa Corporal (IMC) e do tipo de distribuição de gordura corporal por meio da medida da circunferência da cintura (CC) é de suma importância, pois idosos com maior acúmulo de gordura na região abdominal e ou global apresentam estreita relação com alterações metabólicas, as quais, quando associadas ao DM2, aumentam o risco para doença cardiovascular (KLEIN *et al.,* 2007; PREIS *et al.,* 2009; FLINT *et al.,* 2010).

O acúmulo de gordura no abdômen é acompanhado de uma diminuição significante na sensibilidade insulínica (FERRANNINI *et al.,* 2008), e, quando associado a outros fatores, tais como hipertensão (SCHOLZE *et al.,* 2010), dislipidemia e obesidade global (WANNAMETHEE *et al.,* 2005), interferem negativamente no controle metabólico assim como elevam os riscos para a ocorrência de doenças cardiovasculares e metabólicas (GRUNDY *et al.,* 2005; DEPRÉS, 2008; RYAN, 2010; LI *et al.,* 2011).

2.4. Redução da Capacidade Funcional

A capacidade funcional (CF), capacidade de executar atividades típicas e desejáveis na sociedade, refere-se ao grau de preservação do indivíduo quanto ao desempenho de suas Atividades de Vida Diária (AVD), e ainda, ao fato de realizar as Atividades Instrumentais de Vida Diária (AIVD) (HUNG *et al.,* 2011). O conceito de incapacidade reflete as consequências da deficiência sobre o desempenho funcional e a atividade do indivíduo no âmbito pessoal, ou seja, as restrições quanto à execução de suas atividades diárias. O termo desvantagem corresponde às perdas sofridas pelo indivíduo como resultado da deficiência e/ou da incapacidade, refletindo na interação e adaptação desse indivíduo com o meio social. Representa a restrição social do indivíduo, transformando-se em um importante preditor de mortalidade (FENLEY *et al.,* 2009; YAM *et al.,* 2009).

As doenças crônicas, dentre elas o DM2, têm influência na CF da pessoa idosa, ou seja, o seu surgimento está diretamente relacionado à maior redução da capacidade funcional. Dessa forma a melhora ou, no mínimo, a manutenção da CF tem sido um dos objetivos mais importantes e desafiantes no acompanhamento da evolução clínica desses idosos (SINCLAIR *et al.,* 2008; KALYANI *et al.,* 2010), sendo um dos requisitos para um envelhecimento saudável (JOHNSON *et al.,* 2007).

O efeito negativo do diabetes sobre o número de anos vividos reduz a expectativa de vida por cerca de 4 a 10 anos, principalmente quando associado a deficiências funcionais e menos anos de boa saúde autopercebida. Independentemente do estado de diabetes, as mulheres vivem mais, embora enfrentem uma carga de incapacidade maior que os homens (ANDRADE, 2010).

Vários fatores têm sido relacionados ao desenvolvimento de dependência parcial ou incapacidade funcional em idosos diabéticos, incluindo gênero (ANDRADE, 2010), pior controle glicêmico (KALYANI *et al.,* 2010), baixo desempenho cardiorrespiratório (HOLLENBERG *et al.,* 2006; MORIE *et al.,* 2010), doenças cardiovasculares e comorbidades (MELZER *et al.,* 2005; MACIEJEWSKI *et al.,* 2009).

2.5. Riscos Cardiovasculares e Metabólicos

A doença cardiovascular (DCV) é a principal causa de morte entre os indivíduos com diabetes. Para os indivíduos com diabetes tipo 2 aumenta-se o risco de complicações micro e macrovasculares (ADA, 2011). De acordo com as diretrizes da Associação Canadense de Diabetes, as principais intervenções para reduzir o risco de DCV incluem o controle de glicose e dos níveis lipídicos no sangue bem como o controle da pressão arterial (CDA, 2008).

A hiperglicemia presente no DM2 ocasiona o comprometimento da função endotelial, aumentando o risco de surgimento ou agravamento de DCV. Além do aumento da glicose, a dislipidemia, a hipertensão e a obesidade são também fatores de risco comuns para DCV em pessoas com diabetes (BOOS *et al.,* 2006).

A Hipertensão Arterial Sistêmica (HAS) pode estar associada, ou mesmo, fazer parte de um conjunto de fatores de risco metabolicamente interligados, os quais irão determinar a presença futura de complicações cardiovasculares (HENDRIKS *et al.,* 2012). Indivíduos hipertensos frequentemente apresentam altos níveis de colesterol, obesidade, frequência cardíaca elevada, hipertrigliceridemia e diabetes mellitus (MARTE, SANTOS, 2007).

A combinação de obesidade e sedentarismo ou falta de aptidão física (HU *et al.,* 2007; SUI *et al.,* 2007) assim como a má distribuição corporal do tecido adiposo associada à presença do DM2 elevam o risco de morbimortalidade nos idosos por eventos cardiovasculares e metabólicos (PALMER *et al.,* 2009). Ainda, a soma de todos esses fatores fortalece a presença da Síndrome Metabólica (PEMMINATI *et al.,* 2010).

O sedentarismo tem efeito direto sobre a função e a estrutura vascular, estando associado a um maior tônus vasoconstrictor e a efeitos profundos e rápidos no remodelamento das artérias de grande e pequeno calibre, o que explica, em parte, a ligação do risco cardiovascular com o descondicionamento físico (THIJSSEN *et al.,* 2010).

2.6. Baixo Desempenho Cardiorrespiratório

O baixo desempenho cardiorrespiratório vem sendo observado sob a condição diagnóstica de Diabetes, tanto em animais (RODRIGUES *et al.,* 2007), quanto em indivíduos adolescentes (KOMATSU *et al.,* 2007), adultos e idosos (REGENSTEINER *et al.,* 2009), resultando a redução da capacidade de exercício, dependente provavelmente de vários fatores fisiológicos, entre os quais, a atividade neuromuscular, hemodinâmica, mecânica respiratória e consumo de oxigênio.

Especificamente para o idoso diabético, o desempenho cardiorrespiratório (DCR) diminui com o avanço da idade e está associado à presença de doenças crônicas, como a HAS (SHOOK *et al.,* 2012), o que pode ser intensificado com a presença de dislipidemia e sobrepeso (WONG *et al.,* 2004; JACKSON *et al.,* 2009; IRVING *et al.,* 2011). O baixo DCR faz com que qualquer tarefa submáxima seja percebida como sobrecarga em virtude do aumento do gasto energético, causando fadiga precoce e redução das atividades funcionais e, consequentemente interferindo na qualidade de vida (FLEG *et al.,* 2005).

O DCR pode ser avaliado por meio do teste de exercício máximo ou submáximo, o qual usualmente é realizado com o objetivo de investigar a presença de sinais e sintomas de doenças ou avaliar o resultado de intervenções terapêuticas. Os resultados do teste ergoespirométrico (TEE), também conhecido como teste cardiopulmonar de exercício (TCPE), podem ser utilizados como um indicador da capacidade cardiorrespiratória no DM2, sendo útil em estudos que investigam o efeito fisiológico de exercício agudo ou crônico (GUIMARÃES *et al.,* 2003; RODRIGUES *et al.,* 2007; MENEGHELO *et al.,* 2010). O TEE é um procedimento no qual o indivíduo é submetido a um esforço físico programado e individualizado com a finalidade de se avaliarem as respostas clínica, hemodinâmica, autonômica, eletrocardiográfica, metabólica e ventilatória ao exercício. Possibilita, também, diagnosticar e estabelecer o prognóstico de determinadas doenças cardiovasculares, prescrever exercício e avaliar objetivamente os resultados de intervenções terapêuticas (GUIMARÃES *et al.,* 2003; MENEGHELO *et al.,* 2010).

2.7. Interpretação Ergoespirométrica e DCR

A análise e interpretação clínica dos resultados do TEE são essenciais na identificação de pacientes com maior risco de complicações cardiovasculares relacionadas ao exercício. Tal risco deve ser avaliado antes do início do treinamento, usando, também, uma avaliação padronizada para identificar pacientes que podem ter sintomas instáveis ou outros fatores que os caracterizam como um risco aumentado de eventos cardiovasculares adversos (WENGER, 2008).

O teste da integridade do sistema cardiorrespiratório por meio de sua resposta ao exercício permite as determinações objetivas de: ventilação pulmonar (VE), consumo máximo de oxigênio (VO_{2max}), maior valor de oxigênio alcançado no pico do exercício (VO_{2pico}), produção de gás carbônico (VCO_2), equivalente ventilatório do oxigênio (VE/VO_2) e equivalente ventilatório do gás carbônico (VE/VCO_2). Trata-se de um procedimento seguro e eficaz para avaliar as respostas cardiovasculares, mesmo em indivíduos idosos com patologias associadas (YASBEK Jr. *et al.,* 1998; MENEGHELO *et al.,* 2010).

A VE é o volume de ar, que se move para dentro e para fora dos pulmões, expresso em litros por minuto. É determinada pelo produto da frequência respiratória e pelo volume de ar expirado a cada ciclo. O produto da VE pelo oxigênio consumido, ou seja, a diferença entre o conteúdo de oxigênio inspirado e expirado determina o consumo de oxigênio (VO_2) (GUIMARÃES *et al.,* 2003; MENEGHELO *et al.,* 2010).

O VO_2 é uma medida objetiva da capacidade funcional, ou seja, da capacidade do organismo em ofertar e utilizar o oxigênio para a produção de energia. Este aumenta linearmente com o trabalho muscular crescente. Não há um critério bem definido, mas é comumente caracterizado como VO_{2max} ou VO_{2pico} o maior valor de VO_2 efetivamente medido sob certas condições e observado próximo ou no momento da exaustão, ou seja, ao final do teste cardiorrespiratório (CAPUTO, DENADAI, 2008).

O ritmo acelerado de declínio do VO_{2pico} ocasiona implicações substanciais no que diz respeito à independência funcional e qualidade de vida, não só em pessoas idosas saudáveis mas particularmente quando déficits relacionados à doença são sobrepostos (FLEG *et al.,* 2005).

O limiar anaeróbico é também um indicador de desempenho cardiorrespiratório, utilizado na prática para diagnóstico e prognóstico de desempenho funcional de idosos. Um teste de nível de esforço progressivo, em que são medidas as trocas gasosas e o VO_2 no limiar anaeróbico, permite a medição dos fenômenos associados à acidose metabólica em desenvolvimento. À medida que aumenta o nível de esforço, VO_2 e VCO_2 aumentam de forma linear (GUIMARÃES *et al.,* 2003; MENEGHELO *et al.,* 2010).

Durante o esforço crescente, as relações VE/VO_2 e VE/VCO_2 diminuem, progressivamente, e depois aumentam até o final do esforço. O VE/VO_2 reflete a necessidade ventilatória para um dado nível de VO_2, apresentando-se portanto, como um índice da eficiência ventilatória. Pacientes com uma relação inadequada entre a ventilação e a perfusão pulmonar ventilam ineficientemente e possuem altos valores para o VE/VO_2 (GUIMARÃES *et al.,* 2003; ARMSTRONG *et al.*, 2005; MENEGHELO *et al.,* 2010).

O VE/VCO_2 representa a condição ventilatória para se eliminar uma determinada quantidade de CO_2 produzido pelos tecidos em atividade. Após uma queda no início do exercício, o VE/VCO_2 não aumenta durante o esforço submáximo, entretanto, na presença de insuficiência cardíaca crônica, os valores do VE/VCO_2 são desviados para cima, quando comparados aos valores em condições normais. Valores elevados é uma característica da resposta ventilatória anormal ao exercício (GUIMARÃES *et al.,* 2003; ARMSTRONG *et al.,* 2005; MENEGHELO *et al.,* 2010).

As variáveis citadas são de fundamental importância na detecção do limiar anaeróbico, pois incidem no fato de que exercícios realizados numa intensidade acima dele podem provocar um aumento abrupto nos níveis de catecolaminas, causando arritmia, hipertensão e isquemia do miocárdio (YASBEK Jr. *et al.,* 1998).

2.8. Efeitos do Sedentarismo nas Complicações do Diabetes

A atividade física (AF) vem sendo mencionada como instrumento de recuperação, manutenção e promoção da saúde. Embora seja um elemento chave na prevenção e no controle do DM2, muitos idosos apresentam dificuldades em permanecerem regularmente ativos (COLBERG *et al.,* 2010). A má condição de saúde, possivelmente vivida pelo idoso diabético, pode limitar ou restringir a AF quanto à frequência e à intensidade (JANNEY *et al.,* 2010). Essas limitações provocam um prevalente comportamento sedentário nessa população, exacerbando os prejuízos estruturais, metabólicos e fisiológicos frente ao envelhecimento e às doenças crônicas, entre elas o DM2 (REJESKI, BRAWLEY, 2006).

A inatividade física, denominada sedentarismo, é evidenciada em todos os países, sobretudo nos países em desenvolvimento. No Brasil, há um leve incremento do sedentarismo com o aumento da idade cronológica, mas, principalmente, um decréscimo significante na porcentagem de indivíduos muito ativos entre as faixas etárias mais avançadas (ZAITUNE *et al.,* 2007; SIQUEIRA *et al.,* 2008). Essa condição, quando associada ao DM2 e ao processo de envelhecimento, tem apresentado altas prevalências entre os fatores de risco para depressão (KOOPMANS *et al.,* 2009; WIM *et al.,* 2011), declínio funcional (ARAKI, ITO, 2009), dislipidemia, obesidade e morbi-mortalidade cardiovascular (DI FRANCESCO *et al.,* 2005; GINSBERG, MACCALLUM 2009; ADA, 2011).

A relação entre depressão e comportamento sedentário na população idosa tem sido amplamente pesquisada, indicando uma associação significante (TEYCHENNE *et al.,* 2008; BLAKE *et al.,* 2009; KU *et al.,* 2009). De forma inversa, a AF tem efeitos protetores e terapêuticos para uma série de doenças mentais em pessoas idosas (CHODZKO-ZAJKO *et al.,* 2009) e, quando realizada regularmente (CONN, 2010), com maior intensidade, independente da duração, está associada ao menor risco de sintomas depressivos em idosos (CHEN *et al.,* 2012).

A inatividade física é, também, um fator de risco para a dependência funcional entre os idosos (CHRISTENSEN *et al.,* 2006). A maior prevalência de incapacidade funcional nas AVD e AIVD tem sido observada em idosos sedentários e com sobrepeso (DI FRANCESCO *et al.,* 2005). Moderados e altos níveis de atividade física parecem ser eficazes em conferir um risco reduzido de limitações funcionais ou de dependência. Intervenções direcionadas aos idosos que utilizam exercícios aeróbicos e de resistência mostraram melhora nas medidas fisiológicas e funcionais, reduzindo, em longo prazo, a incidência de incapacidade funcional (PATERSON, WARBURTON, 2010).

Em idosos com DM2, um comportamento sedentário associado às alterações negativas no metabolismo lipídico são preditores de declínio das AIVD (SAKURAI *et al.,* 2012). Um dos efeitos deletérios do sedentarismo sobre o perfil metabólico do músculo esquelético desses indivíduos é um pior funcionamento dos processos enzimáticos envolvidos no metabolismo lipídico no fígado e nos músculos. Esse fato diminui a habilidade do tecido muscular de consumir ácidos graxos e reduz a atividade enzimática. Isso favorece um menor catabolismo das lipoproteínas ricas em TG, maior formação de partículas LDL-C aterogênicas e menor produção de HDL-C (NESTO, 2008; LIRA *et al.,* 2012).

De acordo com a IV Diretriz Brasileira sobre Dislipidemias e Prevenção da Aterosclerose, a atividade física regular se constitui uma medida auxiliar para o controle das dislipidemias e o tratamento de DCV (SPOSITO *et al.,* 2007). Indivíduos ativos fisicamente apresentam níveis séricos mais baixos de CT, TG e LDL e concentrações mais elevadas de HDL em relação aos inativos. Essa combinação é considerada protetora, pois associa o baixo teor de lipídios e lipoproteínas, que causam malefício à concentração elevada de HDL, responsável pela mobilização dos lipídios da parede arterial (ZANELLA *et al.,* 2007).

O risco aumentado de dislipidemia, DCV, DM2 e HAS está fortemente relacionado à associação do sobrepeso com sedentarismo, aumentando com o avançar da idade (WONG *et al.,* 2004; JACKSON *et al.,* 2009; IRVING *et al.,* 2011). Um estilo de vida sedentário deve ser combatido em indivíduos com sobrepeso e obesos com resistência à insulina para reduzir o risco de eventos cardiovasculares (RYAN, 2010).

O sedentarismo e o treinamento físico têm efeitos diretos sobre descondicionamento e condicionamento vascular, respectivamente, podendo provavelmente modificar o risco cardiovascular (THIJSSEN *et al.,* 2010). A natureza anti-inflamatória do exercício físico (PETERSEN, PEDERSEN, 2005) tem sido associada à redução da doença cardiovascular, particularmente devido ao aumento da expressão de antioxidantes e dos mediadores anti-inflamatórios na parede vascular, o que pode inibir diretamente o desenvolvimento de aterosclerose (WILUND, 2007).

Os exercícios aeróbicos e de força provocam uma série de respostas favoráveis, entre elas a melhora do controle glicêmico, o aumento da sensibilidade à insulina e a redução dos fatores de riscos cardiovasculares, tais como a adiposidade visceral, perfil lipídico, rigidez arterial (EVES, PLOTNIKOFF, 2006) e função endotelial em DM2 (KWON *et al.,* 2011). No entanto, para os idosos com DM2, a presença de complicações diabéticas ou condições coexistentes, tais como obesidade ou doença cardiovascular, podem impedir a participação em atividades físicas, principalmente aeróbicas (DUNSTAN *et al.,* 2006).

O exercício, mesmo sendo recomendado no tratamento da DM2, é reconhecido como uma forma de estresse fisiológico, que provoca dano oxidativo celular, frequentemente representado por modificações de macromoléculas, incluindo ácidos nucleicos, proteínas e lipídios (FISHER-WELLMAN, BLOOMER, 2009). O consumo máximo de oxigênio é uma das vias potenciais, que relacionam a produção de oxidante com o exercício (DEATON, MARLIN, 2003; BLOOMER *et al.,* 2005; NOJIMA *et al.,* 2008).

Qualquer que seja o exercício, ele não deve ser iniciado antes de uma avaliação criteriosa do estado geral do idoso diabético e sedentário, principalmente havendo a presença de fatores complicadores comumente associados ao DM2. Para tanto, torna-se necessária a avaliação dos efeitos do sedentarismo sobre os aspectos emocionais, funcionais e metabólicos em idosos diabéticos, para que os profissionais de saúde envolvidos nas áreas afins possam conhecer um pouco mais sobre a real capacidade funcional dessa população com provável comprometimento cardiovascular e metabólico.

3. OBJETIVOS

3.1. Geral

- Avaliar os aspectos emocionais, funcionais e metabólicos relacionados ao sedentarismo em idosos diabéticos.

3.2. Específicos

- Correlacionar as variáveis antropométricas, o perfil lipídico, a capacidade funcional e o nível de atividade física e determinar os possíveis preditores da ocorrência de sintomas depressivos em idosos diabéticos.

- Descrever a influência do DM2 no desempenho cardiorrespiratório de idosos hipertensos e sedentários.

- Comparar os efeitos da execução do teste ergoespirométrico sobre as variáveis lipídicas de indivíduos sedentários com hipertensão arterial e com hipertensão arterial associada ao DM2.

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5. ARTIGO 1

Can the interaction of functional decline, LDL-C and HDL-C concentrations, and reduced physical activity predict depressive symptoms in the diabetic elderly?

A interação de declínio funcional, concentrações de LDL-C e HDL-C e redução da atividade física pode predizer sintomas depressivos em idosos diabéticos?

DIABETES, OBESITY AND METABOLISM
A JOURNAL OF PHARMACOLOGY AND THERAPEUTICS

Can the interaction of functional decline, LDL-C and HDL-C concentrations, and reduced physical activity predict depressive symptoms in the diabetic elderly?

Journal:	*Diabetes, Obesity and Metabolism*
Manuscript ID:	Draft
Manuscript Type:	Original Paper
Date Submitted by the Author:	n/a
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Key Words:	dyslipidaemia, type 2 diabetes, exercise, diabetes complications

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Abstract

Aims: Analyze the interaction of functional capacity, biochemical concentrations, and physical activity levels with depressive symptoms and verify whether these domains were predictors of these symptoms in the type 2 diabetic elderly. **Materials and Methods**: Cross-sectional study. The sample consisted of 85 subjects submitted to evaluation for body mass index, depressive symptoms screening (GDS_S), functional capacity ($IADL_S$), biochemical concentration, and physical activity level (T_{MIA} and sedentariness). The sample was classified according to the presence or absence of depressive symptoms, functional decline, and sedentariness. The Mann-Whitney, Chi-Square, Fisher's exact, Spearman's Correlations tests and The Multiple Linear Regression were applied, being significant for $p<0.05$. **Results**: Depressive symptoms and sedentariness were associated with $IADL_S$ ($p<0.001$ and $p=0.011$, respectively) and HDL-C concentrations ($p=0.023$ and $p<0.001$, respectively), while functional decline was associated with GDS_S ($p=0.001$) and T_{MIA} ($p<0.001$). There were positive correlations of HDL-C *vs.* T_{MIA} (*rho*=0.423, $p<0.001$), T_{MIA} *vs.* $IADL_S$ (*rho*=0.507, $p<0.001$), LDL-C *vs.* GDS_S (*rho*=0.213, $p=0.050$) and inverse correlations of GDS_S *vs.* HDL-C (*rho*=-0.273, $p=0.011$), GDS_S *vs.* T_{MIA} (*rho*=-0.241, $p=0.027$), GDS_S *vs.* $IADL_S$ (*rho*=-0.352, $p=0.001$). $IADL_S$, LDL-C, HDL-C and T_{MIA} produced multiple R of 55.2% as predictors of GDS_S (ANOVA, $p<0.001$). **Conclusions**: Diabetic elderly patients with depressive symptoms showed higher functional decline, worse HDL-C and LDL-C concentrations, and low physical activity levels. These domains interacted with each other, reflecting in the predictive capacity of these symptoms. New strategies to prevent the onset of depressive symptoms in this population should slow the functional decline progression, control dyslipidaemia and encourage regular moderate intensity physical activity.

Keywords: functional decline, LDL-C, HDL-C, physical activity level, depressive symptoms, diabetic elderly

Introduction

Diabetes Mellitus (DM) has become a global epidemic. In the elderly population this prevalence rises and usually the disease appears in its most common form, Type 2 Diabetes Mellitus (T2DM) [1]. T2DM has been associated with depressive symptoms [2, 3], functional disability [4, 5], overweight, physical inactivity [1, 6] and cognitive impairment [7]. In turn, the increased prevalence of depression, obesity and physical inactivity, as well as the distribution of body fat increase the risk of morbidity and mortality from cardiovascular and metabolic disorders [8, 9].

Depressive symptoms promotes physical inactivity in patients with T2DM [10], and it is associated with functional dependence [11], cognitive decline [12] and a worse metabolic profile [13, 14]. However, it is known that physical activity is an important component in the treatment of T2DM and for the promotion of healthy aging as it improves insulin sensitivity [6], glycemic control, and reduces cardiovascular risk factors such as hypertension and dyslipidaemia [1]. Moreover, physical activity slows the reduction of functional capacity and the loss of autonomy due to aging [6, 15].

The onset of depressive symptoms is considered multifactorial [5, 11, 16, 17]. However, the summative effects of functional capacity, biochemical concentrations and physical activity levels have not yet been fully understood when associated with such symptoms. Therefore, this study aimed to analyze the interaction of these variables and determine whether they can be potential predictors of depressive symptoms in the diabetic elderly.

Materials and Methods

Study Design

The present cross-sectional study was carried out with a sample of elderly patients from the city of Recife, Brazil, and was held from April to July 2011. The project was approved by the Institutional Human Research Ethics Committee (CAAE: 0127.0.106.000-09). The participants signed a Free and Clarified Consent Term.

Study Patients

For the sample selection, 3.271 medical records of subjects aged over 60, male and female, who were being followed up in Geriatric and Endocrinology Clinics of a public university in Recife were initially assessed. From these, 871 had been diagnosed with T2DM for more than 2 years.

These diabetic elderly were contacted by telephone and invited to participate in the study. From the total, 198 volunteered to participate. After the assessment of their medical records, the subjects who were on insulin, had cognitive impairment, neurological sequelae, severely decreased visual and/or hearing acuity, joint and/or muscle pain, lower limb amputations, wore prostheses and/or presented physical limitations that would hinder mobility, were excluded.

After applying the eligibility criteria, the sample was reduced to 122 individuals. From these, 37 refused to do the blood test, leading to a final sample of 85 diabetic elderly.

Study Size

The sample size was calculated in a pilot study based on the classification of individuals with and without depressive symptoms, considering the GDS scale scores [18] from the first ten individuals allocated in each classification. According to this criterion, having as parameters the difference between two independent means (two groups), two tails, $\alpha=0.05$ and Power=0.95, it would take only 10 subjects, 5 for each classification [19]. However, since the prevalence of depressive symptoms in the diabetic elderly is around 18% [2] and counting on 122 patients eligible for the study, it was estimated a sample of 80 individuals for a 95% confidence level and 5% sampling error.

For ethical reasons, all individuals who attended the eligibility criteria, participated in the assessment tests, and made explicit their willingness to participate for the purpose of self-knowledge and clinical follow-up, were included in the sample group. Thus, the final sample totaled 85 individuals.

Study Assessments

The patients were submitted to evaluation for body mass index (BMI) measure, depressive symptoms screening, functional capacity, assessment of biochemical concentrations and physical activity level tests, following these procedures:

- Body mass index (BMI) was obtained by two primary measures: Weight divided by square height (kg/m^2). In order to classify the nutritional status from the BMI, the cutoff points recommended for the elderly population was used: malnutrition (<22 kg/m^2), eutrophy (22 to 27 kg/m^2) and overweight (>27 kg/m^2) [20].

- Depressive symptoms screening with the Yesavage Geriatric Depression Scale - reduced version (GDS-15), where the result from 0 to 4 points characterized the absence of depression and 5 points or more the presence of depressive symptoms [18]. Depressive symptoms were also analyzed quantitatively based on the scores obtained in each assessment (GDS_S).

- Assessment of functional capacity was quantitatively analyzed based on the scores obtained in the Instrumental Activities of Daily Living (IADL) [21]. This scale has as maximum score 27 points, with the following classification: (27-26 points), partially dependent (25-10 points) and dependent (<10 points). The presence of functional decline was seen in those patients who had complete or partial dependence on IADL.

- Assessment of biochemical determinations: Venous blood samples were drawn from an antecubital vein early in the morning in a fasting state and assessed by a biochemical laboratory. The measured parameters included: Fasting plasma glucose (FPG), lipid profile (serum triglycerides _ TG, serum total cholesterol _ TC, serum low density lipoprotein cholesterol _ LDL-C, serum high density lipoprotein cholesterol _ HDL-C). Serum biochemistries were performed by automated enzimatic method, under routine laboratory procedures. The LDL-C was calculated using the Friedewald formula [22]. The normal values for parameters FPG, TG, TC, LDL-C, HDL-C used in this research were defined by the revised National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) [23].

- Physical activity level assessment performed with the International Physical Activity Questionnaire (IPAQ), which uses the previous 7 days as reference period. This questionnaire was validated in a Brazilian population and in an interview approach. It contains questions regarding frequency and duration of physical activities, classifying the elderly in four categories: very active, active, irregularly active, and sedentary [24]. The physical activity level was investigated considering two variables: Sedentariness and "Time of moderate intensity activities" (T_{MIA}). The presence of sedentariness was established in those subjects who were classified as sedentary and all other classifications were grouped as absence of sedentariness. The T_{MIA} referred to the time self-reported by the subjects, weekly, in minutes spent in performing moderate intensity activities , calculated according to the answers to questions 2a and 2b from IPAQ, as follows: T_{MIA} = (*n days*) x (*time in min*).

Statistical Analysis

Descriptive analysis was used to characterize the sample. The tests applied were Kolmogorov-Smirnov for normality, and Mann-Whitney, Fisher's exact and Pearson Chi-Square for associations. The study of Spearman's Nonparametric correlations was conducted to verify the interaction between depressive symptoms, functional capacity, biochemical determinations, and physical activity level. Multiple Linear Regression was performed to predict GDS, testing as predictors the variables with significant linear correlations. Backward model was used with entry criteria for P=0.05 and removal criteria for P=0.10. It was considered as the final model the one which p related to the change of F with ANOVA and adjusted ß coefficients were significant. The results are presented in tables and figures below. The statistical analysis was performed using the software SPSS (Statistical Package for the Social Sciences), Version 15.0, being considered significant results for p<0.05.)

Results

General characteristics and association of categorical variables according to depressive symptoms:

The study sample consisted of 85 type 2 diabetic subjects, with a mean age of 70.6 (±7.4). Depressive symptoms were present in 29.4% of the sample. There were no losses during testing and data analysis.

Most of the sample featured the predominance of females (76.5%), overweight (62.4%), with sedentary lifestyle (58.8%), as well as changes in fasting blood glucose (87.1%). Among the categorical variables, functional capacity and HDL-C levels were significantly associated with depressive symptoms ($p=0.011$ and $p=0.012$, respectively) (Table 1).

Association of quantitative variables according to depressive symptoms, functional decline and sedentariness:

Depressive symptoms and sedentariness had the same association pattern. Both presented significance with $IADL_S$ ($p<0.001$ and $p=0.011$, respectively) and HDL-C concentrations ($p=0.023$ and $p<0.001$, respectively), while functional decline was associated with GDS_S ($p=0.001$) and T_{MIA} ($p<0.001$) (Table 2).

Correlations among quantitative variables:

There were moderate positive correlations of HDL-C *vs.* T_{MIA} (*rho*=0.423, $p<0.001$), T_{MIA} *vs.* $IADL_S$ (*rho*=0.507, $p<0.001$). The other significant positive correlation was weak: LDL-C *vs.* GDS_S (*rho*=0.213, $p=0.050$). All other significant correlations were inverse and weak: GDS_S *vs.* HDL-C (*rho*=-0.273, $p=0.011$), GDS_S *vs.* T_{MIA} (*rho*=-0.241, $p=0.027$), GDS_S *vs.* $IADL_S$ (*rho*=-0.352, $p=0.001$) (Figure 1A).

Multiple linear regression analysis:

The linear regression analysis for GDS_S prediction showed that $IADL_S$, LDL-C, HDL-C and T_{MIA} produced multiple R of 0.552 with adjusted R^2 of 26.9% (model 1), indicating a moderate correlation between observed and predicted values (ANOVA, p <0.001) (Table 3).

The $IADL_S$ and LDL-C standardized ß coefficients were -0.392 and 0.303 (p<0.001 and p=0.002), respectively, suggesting that $IADL_S$ is more relevant than LDL-C in predicting GDS_S. However, the HDL-C and T_{MIA} coefficients were not significant.

Discussion

Main findings

The diabetic elderly showed frequent occurrence of depressive symptoms. These symptoms were associated with functional decline and displayed a linear relationship with an imbalance in the cholesterol fractions. In contrast, the depressive symptoms were positively correlated to the time spent in minutes in weekly physical activity of moderate intensity. Proving the multifactorial trait of depressive symptoms, the GDSs could be predicted by the interaction between functional decline, LDL-C and HDL-C changes and reduced physical activity. But as predictive outcome, functional autonomy accounted for the main protective function for depressive symptoms, followed by low levels of LDL-C.

Study of the associations of depressive symptoms, functional decline and sedentariness:

The frequency of depressive symptoms was high in the diabetic seniors, achieving higher percentages when compared to those reported in other studies [2, 3, 13]. The fact that the prevalences between depressive symptoms and functional decline were similar (29.4% and 27.1%) and strongly associated reinforces the hypothesis of interaction between these domains and the relationship between cause and secondary effect in these patients [5, 25].

The association between depressive symptoms and functional decline observed in this study, pointing out that patients with depressive symptoms had greater functional decline, was recently confirmed in a systematic review which indicated the association between depression and functional impairment in this population [11]. The presence of depressive symptoms doubles the likelihood of limitations in IADL [4], and determines less ability for self-care, hindering the performance of functional and physical activities as well as the lipid control [9, 11].

Depressive symptoms were also associated with HDL-C, with depressive patients presenting lower serum levels, which is consistent with the findings of Lehto et al. [8]. Also in this context, Sutin et al. [26] state that this phenomenon occurs in women only, the predominant gender in this study.

The physical activity level was not directly associated with depressive symptoms, but there were associations between functional decline and T_{MIA} as well as between sedentariness and $IADL_S$ and HDL-C. These facts demonstrated indirect relationship between physical activity level and depressive symptoms in our sample. The non association between depressive symptoms and physical activity may have occurred due to the dispersion of IPAQ scores, that is, the results may have been influenced by the type of physical activity level assessment, which dependend on the patient's self-assessment, taking a subjective character.

Although physical activity is a key element in T2DM prevention and control, many seniors have difficulty staying regularly active [6]. A bad health condition, possibly experienced by the elderly with diabetes may limit or restrict physical activity in its frequency and intensity [27]. Such limitations cause a prevalent sedentary behavior in this population, exacerbating the damage in the structural, metabolic, and physiological systems against aging and chronic diseases, including T2DM [15].

Correlation Diagram Analysis:

The chronic hyperglycemia condition as measured by FPG in this sample seems to be a key point of the interaction between the studied variables initiated by the FPG positive correlation with TC and TG levels. The outcome of such interaction affects GDS_S and $IADL_S$.

This theoretical model can be explained by the hyperglycemia present in T2DM which causes endothelial function impairment, increasing the risk of CVD onset or worsening [28]. Hyperglycemia combined with other risk factors and complications [29], can lead to the development of functional incapacity [30], and higher risk of depressive symptoms, especially when the glucose metabolism is altered [13, 16].

Figure 1 provides an integrated approach to factors related to depressive symptoms in T2DM, which are usually explained in isolation. In sum, the following propositions are highlighted:

- The significant correlations of GDS_S with HDL-C and LDL-C confirm the link between depressive symptoms and cholesterol fractions imbalance, observed by other authors [8, 31].
- The fact that no significant correlations of GDS_S with TG and TC were observed may be due to the absence of a direct or linear relation, which does not invalidate the relationship between these variables, as observed in secondary axes. In the literature, TC performance in T2DM patients is contradictory. According to Egede and Ellis [14], depressive symptoms were associated with increased TC, while for Lehto et al. [32], patients with these symptoms had lower levels of TC, with no significant differences in TG compared to the control group.
- The significant correlations between GDS_S and the variables T_{MIA} and $IADL_S$ suggest that the increase of depressive symptoms is related to less time performing moderate intensity physical activities and lower IADL score, being the latter a reflection of increased functional incapacity. These findings were also suggested by the results obtained in some studies that investigated the association between depressive symptoms, limitations in IADL [4, 11] and lower levels of physical activity, which has been referred to as a worsening factor of these symptoms in this population [3, 9].

Thus, a correlation diagram could be elaborated (Figure 1A) which, besides outlining the key points of interest in the care of type 2 diabetic patients in conditions similar to this sample, it brings the information that in order to lower depression levels and improve functional capacity, the lipid profile and physical activity should be optimized, once the interaction between dyslipidaemia, sedentariness, functional capacity, and depressive symptoms has been identified (Figure 1B).

GDS_S Predictors:

The association and linear correlation analyzes suggested that $IADL_S$, HDL-C and LDL-C concentrations, and T_{MIA} could predict depressive symptoms. Indeed, it was observed that the GDS_S can be predicted by these variables, confirming the multifactorial trait of depressive symptoms [9, 17, 31].

Notably, functional capacity and LDL-C were the best predictors of depressive symptoms, even though only 26.9% of variation in GDS_S predicted values can be explained by the analysis steps, indicating that other factors can also influence GDS_S behavior, accounting for their variations. In this context, this article contributes to point out that functional autonomy exerts the main protective function for depressive symptoms in diabetics and secondarily, the LDL-C.

Although HDL-C has not significantly contributed in the prediction of depressive symptoms, this lipoprotein has been identified by the imbalance it promotes in anabolic and catabolic muscle reactions during the aging process [33]. Moreover, the HDL-C is associated with significant changes in the relationship between inflammation and physical function in the elderly. Inflammation and oxidative damage have been associated with several biological and clinical modifications (e.g. sarcopenia) and play a major role in the age-related physical function decline. Cesari et al. [34] have hypothesized the activation of a vicious cycle involving the reduction of the protective role played by HDL-C, the worsening of the inflammatory/oxidative status, and the impairment of those subsystems necessary for physical functioning.

The contribution of LDL-C as a predictor of depressive symptoms as observed in this study is not an easy task to be explained, because the relationship between mood changes and lipid metabolism still keeps its nature of a not understood relationship [35].

In 2008, a meta-analysis concluded that although there was an inverse relationship between depressive symptoms and LDL-C, there was no strong consistent association between these variables, mainly due to the heterogeneity among individual study [31]. This research included the study of Aijänseppä et al. [36], which the authors refered to as being the first to show an independent association of low LDL-cholesterol concentration with a high amount of depressive symptoms in the elderly. Later, Letho et al. [32] suggested that higher levels of small-particle LDL were not associated with depression, as well. It should be noted that all studies that investigated this relationship in the searched databases were not specific to the diabetic elderly.

More recently, in animal models, it was found that a higher percentage of depression was positively correlated with CT and LDL-C and negatively correlated with HDL-C. Specifically, alterations in three major lipid classes were associated with behavioral depression [35].

A sedentary lifestyle, associated with negative changes in lipid metabolism, is a predictor of IADL decline in elderly patients with type 2 diabetes [17]. But, the deleterious effects of sedentary behavior on the metabolic profile of the skeletal muscle of these individuals can be reversed just with a moderate increase in physical activity [37]. When the intensity of such activity increases, there is an improvement in the functioning of the enzymatic processes involved in lipid metabolism in the liver and muscles. This fact increases the muscle tissue ability to consume fatty acids and increases the enzymatic activity. This favors an increased catabolism of triglyceride-rich lipoproteins, forming less atherogenic LDL-C particles and increasing HDL-C production [38].

The main implication of this study is that early identification of functional decline and sedentariness, through the use of accessible and easy to apply instruments, along with the detection of changes in HDL-C and LDL-C, diagnosed in a simple laboratory test can indicate the presence of moderate depressive symptoms in the diabetic elderly, even before the onset of other comorbidities that relate T2DM with depression, *e.g.*, ADL dependence, cognitive impairment, immobility, cardiovascular diseases, and amputations.

The present study results should be interpreted in view of some limitations. First, the glycated hemoglobin (HbA_{1c}) was not part of the biochemical analysis at CISAM Laboratory and, therefore, the only available data to analyze the patient's glycemic control was the FPG. Second, the IPAQ is a retrospective instrument of self-recall of daily activities performed in the week preceding its application. The period of data collection was the rainy season in northeastern Brazil, which often limits outdoor activities. There is the possibility of seasonal influences that may interfere with physical activity identification.

In conclusion, the depressive diabetic elderly patient requires special efforts from clinical care providers to avoid a potential downward trend in these outcomes over time. Therefore, future studies using randomized controlled trials with follow-up should seek to clarify the relation between LDL-C, HDL-C, depression, and type 2 diabetics in the elderly, so that such interaction can be confirmed or not. Thus, when planning an intervention in the metabolic component, changes can also be made to reduce psychosocial risk factors.

As a recommendation, new strategies to prevent the onset of depressive symptoms in the diabetic elderly should slow the progression of functional decline, control the lipid profile and encourage regular and oriented physical activity of moderate intensity.

Acknowledgments

We thank the staff of the Laboratory of the Amaury de Medeiros Integrated Health Center – University of Pernambuco (CISAM/UPE), by determining the biochemical variables.

Disclosure Statement

None of the authors have conflicts of interest.

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Table 1 General characteristics of elderly with type 2 diabetes and association of categorical variables according to depressive symptoms

Parameters	All (n=85)	Depressive symptoms No (n=60)	Depressive symptoms Yes (n=25)	p
Gender				
Male (♂)	20 (23.5)	15 (25.0)	5 (20.0)	ns
Female (♀)	65 (76.5)	45 (75.0)	20 (80.0)	
Overweight (by BMI)				
No (22 to 27 kg/m²)	32 (37.6)	20 (33.3)	12 (48.0)	ns
Yes (> 27 kg/m²)	53 (62.4)	40 (66.7)	13 (52.0)	
Functional decline (by IADL)				
No (27-26 points)	62 (72.9)	49 (81.7)	13 (52.0)	0.011 (*)
Yes (≤ 25 points)	23 (27.1)	11 (18.3)	12 (48.0)	
Physical activity level (by IPAQ)				
Irregular activity	35 (41.2)	27 (45.0)	8 (32.0)	ns
Sedentary	50 (58.8)	33 (55.0)	17 (68.0)	
FPG (fasting plasma glucose)				
≤ 100 mg/dL†	11 (12.9)	8 (13.3)	3 (12.0)	ns
> 100 mg/dL	74 (87.1)	52 (86.7)	22 (88.0)	
TG (serum triglycerides)				
≤ 150 mg/dL†	51 (60.0)	39 (65.0)	12 (48.0)	ns
>150 mg/dL	34 (40.0)	21 (35.0)	13 (52.0)	
TC (serum total cholesterol)				
≤ 200 mg/dL†	52 (61.2)	36 (60.0)	16 (64.0)	ns
> 200 mg/dL	33 (38.8)	24 (40.0)	9 (36.0)	
LDL-C (low density lipoprotein-cholesterol)				
≤ 100 mg/dL†	45 (52.9)	34 (56.7)	11 (44.4)	ns
> 100 mg/dL	40 (47.1)	25 (43.3)	14 (56.0)	
HDL-C (high density lipoprotein-cholesterol)				
≥ 50(♀) / 40(♂) mg/dL†	59 (69.4)	47 (78.3)	12 (48.0)	0.012 (*)
< 50(♀) / 40(♂) mg/dL	26 (30.6)	13 (21.7)	13 (52.0)	

Categorical variables, n (%). BMI, body mass index; GDS, geriatric depression scale; IADL, instrumental activities of daily living; IPAQ, international physical activity questionnaire. † Values considered suitable for elderly diabetics by NCEP ATP III revised. Pearson Chi-Square and Fisher's exact tests were used for intergroup analysis. $p<0.05$ (*). ns (not significant).

Table 2 Association of quantitative variables (mean ±SD) according to depressive symptoms, functional decline and sedentariness

	Depressive symptoms			Functional decline			Sedentariness		
Parameters	No (n=60)	Yes (n=25)	p	No (n=62)	Yes (n=23)	p	No (n=35)	Yes (n=50)	p
Age (years)	71.3 ±7.6	69.0 ±6.8	ns	70.0 ±6.5	72.3 ±9.5	ns	69.5 ±6.4	71.4 ±8.1	ns
BMI (kg/m²)	29.1 ±4.7	28.3 ±4.9	ns	28.8 ±5.0	28.8 ±5.0	ns	28.4 ±5.1	29.1 ±4.9	ns
GDS_S (points)	2.1 ±1.5	7.3 ±2.7	<0.001(**)	2.9 ±2.3	5.7 ±3.9	0.001(**)	3.0 ±2.5	4.1 ±3.3	ns
$IADL_S$ (points)	25.5 ±2.4	23.3 ±3.3	<0.001(**)	26.3 ±1.0	20.9 ±2.5	<0.001(**)	25.9 ±1.6	24.1 ±3.3	0.011(*)
T_{MIA} (min/week)	56.8 ±62.7	28.4 ±41.5	ns	61.4 ±61.4	13.5 ±29.6	<0.001(**)	113.1 ±33.4	3.1 ±2.5	<0.001(**)
FPG (mg/dL)	154.1 ±63.8	170.8 ±70.5	ns	156.9 ±66.8	164.7 ±64.5	ns	154.4 ±72.4	162.2 ±61.5	ns
TG (mg/dL)	151.8 ±87.8	158.8 ±62.3	ns	192.0 ±45.1	202.3 ±54.4	ns	148.6 ±90.4	157.6 ±74.2	ns
TC (mg/dL)	192.2 ±43.0	201.0 ±57.8	ns	144.8 ±75.2	178.5 ±91.7	ns	197.0 ±43.1	193.2 ±51.0	ns
HDL-C (mg/dL)	61.3 ±21.8	52.0 ±26.7	0.023(*)	60.7 ±23.7	52.8 ±22.7	ns	69.3 ±22.0	51.1 ±21.8	<0.001(**)
LDL-C (mg/dL)	101.4 ±33.7	121.6 ±53.9	ns	105.8 ±35.6	111.5 ±54.8	ns	101.7 ±39.8	111.2 ±42.4	ns

BMI, body mass index; GDS_S, geriatric depression scale - score; $IADL_S$, instrumental activities of daily living - score; T_{MIA}, time of moderate intensity activities; FPG, fasting plasma glucose; TG, serum triglycerides; TC, serum total cholesterol; LDL-C, low density lipoprotein-cholesterol; HDL-C, high density lipoprotein-cholesterol. Mann-Whitney test was used for statistical analysis. $p<0.05$(*). $p<0.01$(**). ns (not significant).

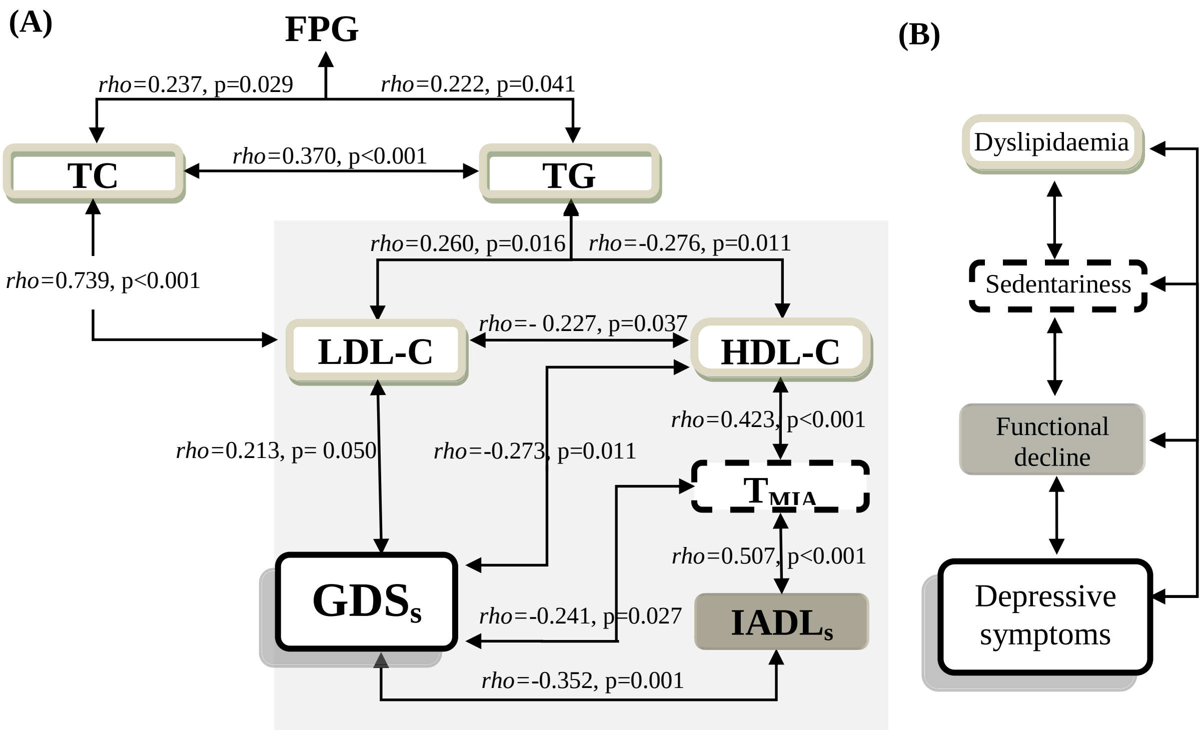

Fig. 1 Spearman's Correlations diagram among lipid (TC, TG, LDL-C, HDL-C), T_{MIA}, $IADL_S$ and GDS_S variables (A). Interaction among lipid, physical activity level, functional and emotional domains (B). FPG, fasting plasma glucose; TC, serum total cholesterol; TG, serum triglycerides; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; T_{MIA}, time of moderate intensity activities; $IADL_S$, instrumental activities of daily living - score; GDS_S, geriatric depression scale - score.

Table 3 Results of multiple linear regression analysis

Model	Predictors	R	R^2	R^2 Adjusted	Change Statistics R^2	Change Statistics Sig. F	ANOVA P
1	$IADL_S$, LDL-C, HDL-C, T_{MIA}	0.552 [(a)]	0.304	0.269	0.304	<0.001	<0.001
2	$IADL_S$, LDL-C, HDL-C	0.551 [(b)]	0.304	0.278	<0.001	0.812	<0.001
3	$IADL_S$, LDL-C	0.535 [(c)]	0.286	0.269	0.018	0.157	<0.001

Dependent Variable: GDS_S, geriatric depression scale - score; [(a)] Predictors: (Constant), $IADL_S$, instrumental activities of daily living - score; LDL-C, low density lipoprotein cholesterol, HDL-C, high density lipoprotein cholesterol; T_{MIA}, time of moderate intensity activities. [(b)] Predictors: (Constant), $IADL_S$, LDL-C, HDL-C; [(c)] Predictors: (Constant), $IADL_S$, LDL-C.

6. ARTIGO 2

Influence of Type 2 Diabetes Mellitus on the cardiorespiratory performance of the hypertensive elderly

Influência do Diabetes Mellitus tipo 2 no desempenho cardiorrespiratório em idosos hipertensos

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Elsevier Editorial System(tm) for American Journal of Cardiology

Manuscript Number:

Title: INFLUENCE OF TYPE 2 DIABETES MELLITUS ON THE CARDIORESPIRATORY PERFORMANCE OF THE HYPERTENSIVE ELDERLY

Article Type: Full Length Article

Keywords: Diabetes Mellitus Type 2; Hypertension; Aged; Physical Fitness; Oxygen Consumption; Sedentary Lifestyle

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INFLUENCE OF TYPE 2 DIABETES MELLITUS ON THE CARDIORESPIRATORY PERFORMANCE OF THE HYPERTENSIVE ELDERLY

ABSTRACT

OBJECTIVE: To compare the cardiorespiratory performance of the hypertensive sedentary elderly and the performance of those who associate T2DM to this clinical condition. **DESING:** Cross-sectional study. **PARTICIPANTS:** The sample consisted of 40 elderly people, male and female, divided into two groups: 20 hypertensive (G1; 68.50 ±5.85 years) and 20 diabetic-hypertensive (G2; 68.95 ±6.79 years). **MEASUREMENTS:** Nutritional status, postprandial glucose (PPG), blood pressure, systolic (SBP) and diastolic (DBP), and cardiorespiratory performance. The significance level was set at $p<0.05$. **RESULTS:** The diabetic elderly presented significant reduction of oxygen consumption in the first anaerobic threshold (VO_{2AT}), time to reach VO_{2AT}, peak oxygen uptake (VO_{2peak}), time to reach VO_{2peak} (TVO_{2peak}) and production of carbon dioxid (VCO_2). Only the G2 showed a significant moderate correlation of TVO_{2peak} with DBP. However, DBP was the variable that most contributed to the prediction of TVO_{2peak}. **CONCLUSION:** The presence of T2DM favored a poorer cardiorespiratory performance in hypertensive and sedentary elderly. The decrease in exercise tolerance found in diabetic patients without apparent heart disease still requires further investigation. The worst ability to physical exertion observed in these subjects implies the discovery of a group of major cardiovascular morbidity and greater therapeutic attention.

Keywords: Diabetes Mellitus; Type 2; Hypertension; Aged; Physical Fitness; Oxygen Consumption; Sedentary Lifestyle

Introduction

The aging process is associated with insulin resistance and glucose intolerance, which contributes to the increase of Type 2 Diabetes Mellitus (T2DM). This fact leads to a real public health problem, considering that diabetics have a higher risk of developing kidney and cardiovascular diseases, as well as heart failure.[1-3]

Several studies link heart failure in diabetic patients with poor exercise aerobic capacity.[4,5] However, exercise tolerance in diabetic patients without apparent heart disease still requires further investigation. A lower physical exertion capacity in non-cardiopathic diabetic individuals would imply in the emergence of a group of higher cardiovascular morbidity and increased need of therapeutic attention.

In the context that the build-up of chronic diseases associated with sedentariness may negatively affect the functional capacity of these individuals, the hypothesis being tested is that T2DM influences cardiorespiratory performance decrease in the hypertensive sedentary elderly.

Thus, the primary objective of this study was to compare the cardiorespiratory performance of the hypertensive sedentary elderly and the performance of those who associate T2DM to this clinical condition and the secondary objectives were to correlate the ergoespirometric with pressure variables and check if the glycemic and pressure variables may be predictors of performance cardiorespiratory.

Methods

Cross-sectional study, held between January and July, 2012, which sample consisted of elderly volunteers, male and female, selected by convenience, dwelling in a community that counted with a Primary Health Care service (PHC).The study was approved by the University Committee on Ethics in Human Research (125/2009 - CAAE: 0127.0.106.000-09) and all seniors involved were informed about the study's risks and benefits and signed a consent form.

The following inclusion criteria were used: 60-years-old or above; diagnosis of arterial systemic hypertension and/or T2DM for at least two years, active member of the PHC hypertension and diabetes mellitus program, be on optimized drug therapy for more than three months, BMI above 22 kg/m²; non-insulin-dependent, no heart disease, sedentary according to the International Physical Activity Questionnaire (IPAQ)[6] and functional independent.[7]

The exclusion criteria were the following: ergospirometry interrupted by adaptive, hemodynamic, and electrocardiographic complications; respiratory exchange ratio (R) lower than 1.0 at the end of exertion, VE/VCO_2 value higher than 34 in the first anaerobic threshold; chronic atrial fibrillation; neuromuscular, orthopedic, peripheral vascular, and pulmonary diseases; myocardial infarction within 6 months; orthopedic limitation or musculoskeletal pain.

The sample calculation was performed using G*Power 3.1© software.[8] It was based on the pilot study results with 10 subjects and two variables: PPG at the sixth minute (PPG_6) of the ergospirometric test and VO_{2peak}. The bilateral assessment test, considering the difference between the means of two independent groups with α=0.05 and Power=0.80, calculated for the VO_{2peak} variable a sample of 16, 8 for each group, and for the PPG_6 variable, 40 subjects, 20 for each group.

The sample recruitment process started with 614 community-dwelling elderly people, from which 162 were hypertensive. Along the program monthly meetings, 63 sedentary patients were selected, being 28 hypertensive, and 35 diabetic hypertensive. The selection was randomly done until n from the sample calculation was reached. After being evaluated by the cardiologist responsible for the ergospirometric test, 23 subjects were excluded, being 8 hypertensive and 15 hypertensive and diabetic. The final sample consisted of 40 subjects with a mean age of 68.93 (±6.72 years), from which 20 had a previous diagnosis of hypertension (G1) and 20 had hypertension associated with T2DM (G2). The gender distribution was 85% female and 15% male in both groups.

The medication used by the elderly was delivered monthly by the Brazilian public health system during medical appointments. It consisted of ACE inhibitors, being captopril the most used medication in both groups G1 (85%) and G2 (90%); beta-blockers, especially propranolol, G1 (45%) and G2 (50%); the diuretic hydrochlorothiazide, G1 (20%) and G2 (15%); and finally hypoglycemic agents for G2 (the T2DM group) only, being metformin the most used (90%). There was no statistical difference intergroups.

The variables analyzed were the nutritional status, postprandial glucose, blood pressure and cardiorespiratory performance.

Procedures used

- Nutritional status assessment - through the primary anthropometric measures weight and height, the body mass index (BMI), weight divided by square height (kg/m^2), was identified.[9]

- Biochemical analysis - two hours after the first meal of the day, two blood samples were collected from one of the upper limbs of the subjects, at rest (B) and in the sixth minute after acute exercise (6) for measuring glucose. The samples were identified and placed in sterile test tubes, and subsequently analyzed with the enzymatic method. Serum was obtained by centrifugation at 5000 rotations per minute (rpm) for 10 minutes and the biochemical analyses were performed with specific laboratory kits.

- Cardiorespiratory performance evaluation with maximum exertion acute exercise - made by trained cardiologist to obtain the measurement of oxygen consumption at anaerobic threshold (VO_{2AT}); time, in seconds, to achieve oxygen consumption at anaerobic threshold (TVO_{2AT}); oxygen ventilatory equivalent (VE/VO_2 l/min); carbon dioxide ventilatory equivalent (VE/VCO_2 l/min); peak oxygen consumption (VO_{2peak} ml/kg/min); time, in seconds, to achieve peak oxygen consumption (TVO_{2peak}); carbon dioxide output (VCO_2 l/min), respiratory exchange ratio (R) in the presence of the patient's usual medication. An ergospirometric test was performed on a Micromed Centrium 300 treadmill, made in Brazil, with the ErgoPC Elite ® software connected to a Micromed electrocardiograph with 11 channels, made in Brazil, in a Cortex Metamax 3B ergospirometer, made in Leipzig, Germany. The ergospirometry room had adequate temperature and humidity and counted with emergency equipment to prevent/treat possible complications. Each individual received recommendation and general orientation about the exam and was introduced to the equipment.[10,11] Then, 11 electrodes were applied with skin contact to facilitate the electrical transmission of the main and peripheral precordial derivations. An oronasal mask with output to a ventilometer connected to the software was attached. The protocol of choice was the ramp increment,[12] with the measurement of dyspnea, blood pressure, oxygen saturation, and ECG leads every two minutes. The test was terminated when the subject presented electrocardiographic changes at rest, during exercise, or requested interruption of effort, even if the thresholds had not been achieved. Upon the patient's request to stop, the treadmill's inclination was quickly brought to 0° and the speed to half the maximum speed achieved with successive decreases of 0.5 meters/second every 30 seconds. Blood pressure, electrical signals, heart rate and oxygen saturation were continuously measured for 06 minutes in order to check any change in response during the cool-down phase. The values were captured breath by breath, under standard conditions of temperature, pressure, and humidity (STPD), at the moment of maximum exertion and at the first ventilatory threshold.

- Blood pressure measurement by the indirect method, with auscultatory technique and aneroid sphygmomanometer (phases I and V of Korotkoff sounds). The elder was sitting, at rest, during the measurement of systolic and diastolic basal blood pressures (SBP_B and DBP_B). The systolic and diastolic blood pressures were also measured in the ergospirometry recovery period in the first and sixth minutes after the test (SBP_1, SBP_6, DBP_1, DBP_6).

Statistic analysis

The sample was characterized by descriptive analysis. The tests applied were Kolmogorov-Smirnov for normality and Mann-Whitney for intergroup associations. The Spearman's nonparametric correlation study was conducted in order to verify the interaction between the ergospirometry, glucose, and blood pressure variables. Multiple Linear Regression was performed to predict TVO_{2peak}, testing as predictors the glucose and basal blood pressure variables. Backward model was used with entry criteria for P=0.05 and removal criteria for P=0.10. It was considered as the final model the one which p referring to the F change with ANOVA was significant. The results are presented in tables and figures. The statistical analysis was performed using the Statistical Package for the Social Sciences, SPSS software, version 15.0, being significant results for p<0.05.

Results

Table 1 characterizes the sample and compares the groups (G1 and G2) for age, body mass index, basal postprandial glucose, basal blood pressure levels, and ergospirometric variables. The results demonstrate comparability between the groups (G1 and G2), except in the PPG_B variable where G2 showed a high level of postprandial glucose. The diabetic elderly presented significant reduction of VO_{2AT}, TVO_{2AT}, VO_{2peak}, TVO_{2peak} and VCO_2.

In the variable correlation analysis, only the hypertensive diabetic elderly (G2) showed a significant moderate correlation in the ergospirometric (TVO_{2peak}) and pressoric (DBP_B) variables, *rho*= -0531, p=0.008, showing an inverse relationship between them (Figure 2).

The linear regression analysis for TVO_{2peak} prediction showed that DBP, SBP and PPG produced multiple R of 0.692 with adjusted R^2 of 38.1% (model 1), indicating a moderate correlation between observed and predicted values (ANOVA, p=0.013). However, DBP was the variable that most contributed to the prediction of TVO_{2peak} (Table 2).

Discussion

The hypertensives and diabetics elderly when subjected to maximum effort exercise consumed less O_2, decreased CO_2 production, producing less energy and thus showing signs of fatigue more quickly. The results found in this study suggest that even diabetic elderly without heart disease deserve to special attention from the attending physician and the scientific community.

The importance of knowledge of the low values of oxygen consumption suggests, in fact, myocardial damage incipient. Knowing that the largest increase in ventricular function and the optimization of Frank-Starling mechanism occur mainly to the first anaerobic threshold,[12-14] the results indicate greater caution in prescribing exercises, cardiovascular rehabilitation, of these subjects, whose ideal heart rate to start physical training should be, in principle, below the first threshold.[15,16]

The diastolic blood pressure was correlated and was also identified as a predictor of shorter execution time of the cardiorespiratory exercise test, but only in the hypertensive diabetic group.

According to Russo et al.,[17] the association of hypertension with diabetes causes negative impact on diastolic function. For Baldi et al.,[18] the diastolic dysfunction is present in a greater extend in the sedentary and diabetic elderly. Corroborating the results of this research, Otto et al.[19] stated that there is a significant correlation between diastolic function and exercise capacity, determining low functional capacity, especially in a sample similar to that of this study: hypertensive, diabetic, and overweight elderly women.

The main limitation of this study was not to perform echodopplercardiogram however, any clinical complaints, changes on physical examination or electrocardiographic abnormalities were exclusion criteria of the study and the participants considered free of heart disease.

In conclusion, T2DM favored a poorer cardiorespiratory performance in hypertensive and sedentary elderly. The decrease in exercise tolerance found in diabetic patients without apparent heart disease still requires further investigation. The worst ability to physical exertion observed in these subjects implies the discovery of a group of major cardiovascular morbidity and greater therapeutic attention, possibly early onset of treatment for heart failure.

Acknowledgement

We thank the staff of the Laboratory of the Amaury de Medeiros Integrated Health Center – University of Pernambuco (CISAM/UPE), by determining the biochemical variables.

Conflict of interest statement

None.

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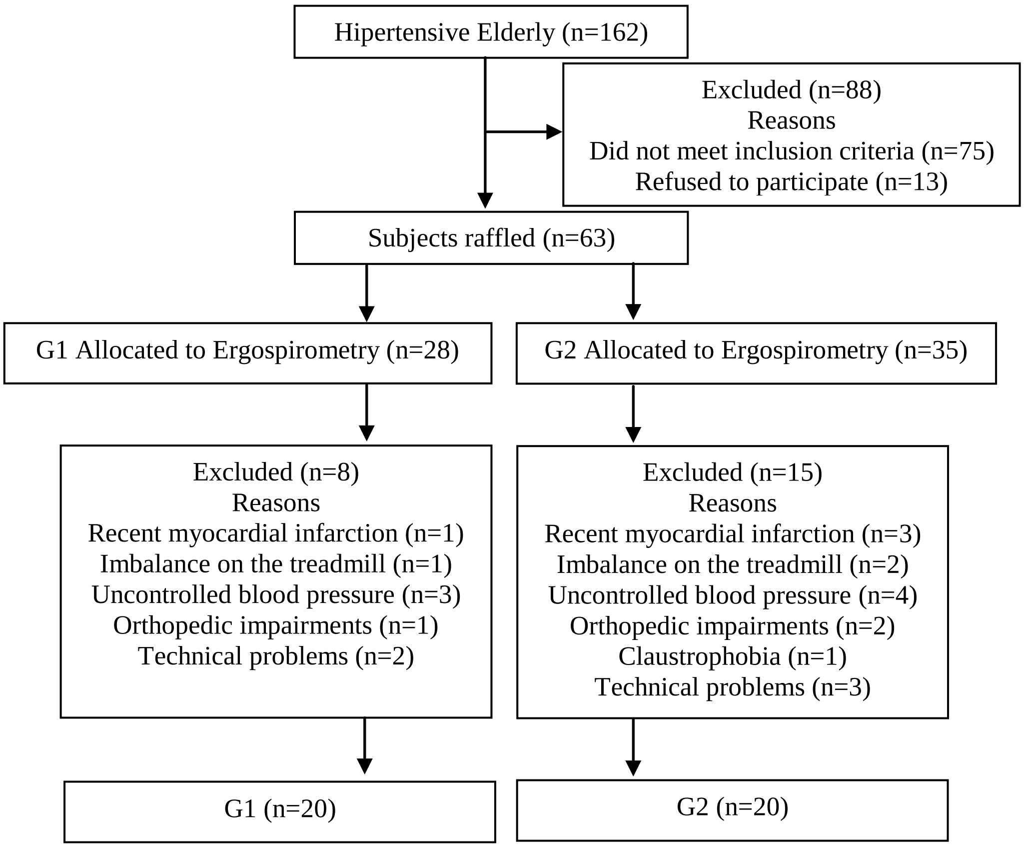

Figure 1. Schematic of subject flow and reasons for exclusion.

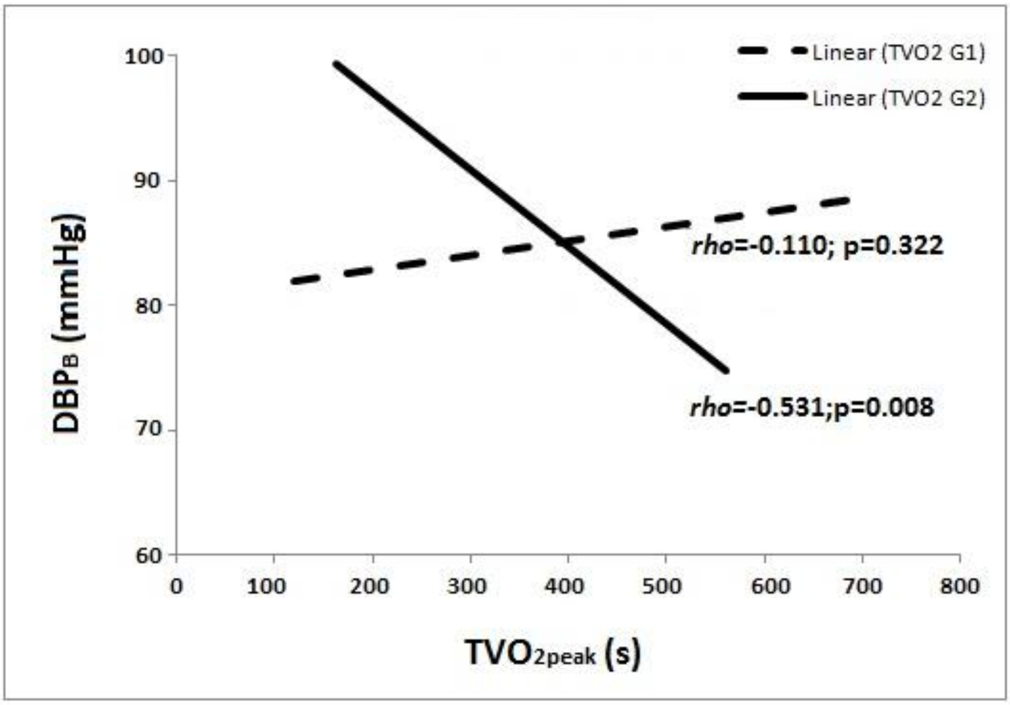

Figure 2. Correlation between Time to reach oxygen uptake at peak exercise (TVO_{2peak}) and Diastolic Blood Pressure (DBP_B) variables. Spearman's Correlations.

Table 1 Characterization of anthropometric, glycemic, pressoric and ergoespirometric variables in the total sample and comparative analysis between groups.

Variables	Total Sample (n=40) Mean ± SD	Groups G1 (n=20) Mean ± SD	G2 (n=20) Mean ± SD	p
Anthropometric				
Age (years)	68.73 ±6.26	68.50 ±5.85	68.95 ±6.79	ns
BMI (kg/m^2)	29.59 ±4.41	28.94 ±4.26	30.24 ±4.57	ns
Glycemic				
PPG_B (mg/dL)	107.63 ±56.46	84.10 ±22.92	131.15 ±69.66	0.013
Pressoric				
SBP_B (mmHg)	128.75 ±13.34	126.75 ±12.59	130.75 ±14.07	ns
DBP_B (mmHg)	82.00 ±5.52	82.00 ±5.23	82.00 ±5.94	ns
Ergospirometric				
TVO_{2AT} (ml/kg/min)	15.66 ±2.97	17.30 ±2.82	14.01 ±2.11	<0.0001(**)
TVO_{2AT} (sec)	294.05 ±132.27	343.95 ±140.97	244.15 ±103.91	0.013(*)
VE/VO_2 (ml/kg/min)	28.70 ±3.73	27.81 ±3.33	29.60 ±3.98	ns
VE/VCO_2 (ml/kg/min)	28.24 ±2.90	27.44 ±2.47	29.01 ±3.14	ns
VO_{2peak} (ml/kg/min)	17.56 ±3.74	19.70 ±3.44	15.42 ±2.71	<0.0001(**)
TVO_{2peak} (sec)	408.10 ±145.59	470.70 ±148.03	345.50 ±115.51	0.005(**)
VCO_2 (ml/kg/min)	19.71 ±4.42	21.91 ±4.49	17.52 ±3.13	0.003(**)
R	1.14 ±0.10	1.16 ±0.12	1.13 ±0.09	ns

BMI (body mass index); PPG_B (postprandial glucose – basal), SBP_B (systolic blood pressure – basal); DBP_B (diastolic blood pressure – basal). VO_{2AT} (oxygen consumption – 1st anaerobic threshold); TVO_{2AT} (time of oxygen consumption – 1st anaerobic threshold); VE/VO_2 (ventilation *vs.* oxygen consumption); VE/VCO_2 (ventilation *vs*. production of carbon dioxid); VO_{2peak} (peak oxygen uptake); TVO_{2peak} (time of peak oxygen uptake); VCO_2 (production of carbon dioxid); R (respiratory exchange ratio). Mann-Whitney test. ns (not significant).

Table 2 Results of multiple linear regression analysis.

Model	Predictors	R	R^2	R^2 Adjusted	Change Statistics R^2	Sig. F	ANOVA p
	TVO_{2peak}						
1	DBP, SBP, PPG	0.692	0.478	0.381	0.041	0.279	0.013 (*)
2	DBP, SBP	0.661	0.438	0.371	0.149	0.048	0.008 (**)
3	DBP	0.537	0.288	0.249	0.288	0.015	0.015 (*)

Dependent Variables: TVO_{2peak} (time to reach oxygen uptake at peak exercise). Predictors: DBP (diastolic blood pressurel). (**) $p \leq 0.01$, (*) $p < 0.05$.

7. **ARTIGO 3**

Can cardiorespiratory performance be influenced by the lipid profile of the diabetic hypertensive elderly? Parallel Trial

O desempenho cardiorrespiratório pode ser influenciado pelo perfil lipídico de idosos hipertensos e diabéticos? Ensaio paralelo

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ClinicalTrials.gov
Protocol Registration System

Protocol Registration Receipt
12/04/2012

Cardiorespiratory Performance in Diabetic Elderly

This study has been completed.

Sponsor:	Universidade Federal de Pernambuco
Collaborators:	
Information provided by (Responsible Party):	Daniella Cunha Brandao, Universidade Federal de Pernambuco
ClinicalTrials.gov Identifier:	**Identifier: NCT01757080**

Can cardiorespiratory performance be influenced by the lipid profile of the diabetic hypertensive elderly? Parallel Trial

ABSTRACT

OBJECTIVE: Compare the ergospirometric test performance effects on the lipid variables of both sedentary individuals with hypertension and those with hypertension associated with diabetes mellitus. **DESING:** Parallel trial study. **PARTICIPANTS:** The sample consisted of 40 elderly people, male and female, divided into two groups: 20 hypertensive (G1; 68.50 ±5.85 years) and 20 diabetic-hypertensive (G2; 68.95 ±6.79 years). **MEASUREMENTS:** Nutritional status; glucose and lipid controls - postprandial glucose (PPG), triglycerides (TG), total cholesterol (TC), low density lipoprotein (LDL-C), very low density lipoprotein (VLDL-C), high density lipoprotein (HDL-C); blood pressure, and cardiorespiratory performance. The significance level was set at $p<0.05$. **RESULTS:** Following the test, the lipid profile as a whole increased in both groups. The G2 subjects reached VO_{2peak} in less time and this was correlated with high levels of LDL-C and diastolic blood pressure. Also, the VE/VCO_2 curve increase was correlated with high plasma concentrations of TG and VLDL-C, as well as low plasma concentrations of HDL-C. Notwithstanding, the LDL and HDL cholesterol fractions were identified as the major predictors of the poor performance of these subjects. **CONCLUSION:** The diabetic hypertensive elderly had a poorer cardiorespiratory performance during testing. The high levels of TG, VLDL-C, and LDL-C, as well as the low HDL-C level potentiated this low performance, regardless the presence of hypertension, overweight, and sedentary lifestyle found in the whole sample studied.

Keywords: Diabetes Mellitus, Type 2; Hypertension; Aged; Dyslipidemias; Physical Fitness; Sedentary Lifestyle

INTRODUCTION

Aging promotes significant increases in inflammatory agents that negatively impact the vasculature, impairing blood flow. This condition is exacerbated in the presence of type 2 diabetes mellitus (T2DM).[1-4]

Hypertension (HTN), dyslipidemia, and obesity, when associated with T2DM, are important risk factors for the development of cardiovascular diseases (CVD) in the elderly. Such condition may increase morbidity or even lead to premature death.[5,6] The combination of these factors causes a prevalent sedentary behavior and promotes the reduction of cardiorespiratory performance, interfering in the functional ability of elderly people to perform their daily activities.[7-9]

Regular physical activity has been one of the main axes of the non-pharmacological treatment program for T2DM. However, any kind of exercise should be initiated only after a careful assessment of the diabetic elderly, especially in the presence of hypertension, another chronic disease commonly associated with T2DM.[10,11]

As part of this review, the cardiorespiratory exercise test, considered gold standard in Exercise Physiology and Geriatric Cardiology, allows the determination of respiratory, metabolic, and cardiovascular disorders by measuring the pulmonary gas exchange during exercise and the expression of functional assessment indices.[12,13]

Opinions about the immediate effect of physical exercise on the control of metabolic changes coming from T2DM are controversial.[14] The results are polemic and, in the elderly population with specific diseases, such as T2DM, they are scarce.[15]

In this context, aiming to expand the possibilities of clinical diagnosis for the establishment of new therapeutic approaches, among them the non-pharmacological ones, this study compared the effects of the execution of ergospirometry test over the lipid variables in two subgroups of sedentary elderly: hypertensive and diabetic hypertensive.

METHODS

Participants

The present parallel trial study was carried out with a sample of elderly patients from the city of Recife, Brazil, and was held from January to June 2012, registred in ClinicalTrials.gov (Identifier: NCT01757080). The project was approved by the Institutional Human Research Ethics Committee (CAAE: 0127.0.106.000-09). The participants signed a Free and Clarified Consent Term.

The sample consisted of community-dwelling elderly volunteers, male and female, who were being followed-up in a program for hypertensive and diabetic patients in a primary health care service (PHC).

The following inclusion criteria were used: 60-years-old or above, diagnosis of hypertension and/or T2DM for at least 2 years, member active of the hypertension and diabetes mellitus program, be on optimized drug therapy for more than 3 months, BMI above 22 kg/m²; no heart disease, non-insulin-dependent, sedentary according to the International Physical Activity Questionnaire (IPAQ)[16] and functionally independent.[17]

The exclusion criteria were the following: ergospirometry interrupted by adaptive, hemodynamic, and electrocardiographic complications; respiratory exchange ratio (R) lower than 1.0 at the end of exertion, VE/VCO_2 value higher than 34 in the first anaerobic threshold; chronic atrial fibrillation; neuromuscular, orthopedic, peripheral vascular, and pulmonary diseases; myocardial infarction within 6 months; orthopedic limitation or musculoskeletal pain.

A sample size calculation was performed based on two variables (VO_{2peak} and PPG) from the pilot study with 10 subjects, α=0.05, Power=0.80. The bilateral assessment test, considering the difference between the means of two independent variables, calculated for VO_{2peak} a sample of 16 subjects, being 8 per group, and for PPG, a sample of 40 subjects, 20 per group.

Figure 1 illustrates the sample recruitment process flowchart. The hypertension and diabetes program followed 162 elderly patients. From these, 74 met the inclusion criteria and were referred to clinical assessment by sampling strata of n=5 with replacement, until reaching the n fixed in the sample calculation.

The subject selection was done randomly in sequentially numbered, opaque, and inviolable envelope. The researcher who generated the allocation sequence was not involved in patient eligibility or in data collection, keeping, therefore, the allocation concealment and investigator blinding about which group the subjects belonged to.

The eligibility confirmation was made with clinical and ergospirometric evaluation held by a cardiologist. In total, 63 eligible seniors were divided into two groups: hypertension (G1, n=28) and hypertension associated with T2DM (G2, n=35). The intervention was discontinued for 23 subjects, being 8 hypertensive and 15 diabetic hypertensive. So, the sample consisted of 40 subjects, 20 in each group.

The medication used by the elderly was monthly distributed by the Brazilian public health system during medical appointments. It consisted of ACE inhibitors, being captopril the most used medication in both groups G1 (85%) and G2 (90%); beta-blockers, especially propranolol, G1 (45%) and G2 (50%); the diuretic hydrochlorothiazide, G1 (20%) and G2 (15%); and finally, hypoglycemic agents for G2 (the T2DM group), being metformin the most used (90%). There was no statistical difference intergroups.

The variables analyzed were the following: Nutritional status, glucose and lipid controls (postprandial glucose, PPG mg/dL), triglycerides (TG mg/dL), total cholesterol (TC mg/dL), low density lipoprotein (LDL-C mg/dL), very low density lipoprotein (VLDL-C mg/dL) and high density lipoprotein (HDL mg/dL), blood pressure, and cardiorespiratory performance.

Measures

The following procedures were performed:

- Nutritional status - through the primary anthropometric measures, weight and height, the body mass index (BMI) was calculated: weight divided by square height (kg/m2). In order to classify the nutritional status from the BMI, cutoffs recommended for the elderly population were applied: malnutrition (<22 kg/m^2), normal weight (22-27 kg/m^2) and overweight (> 27 kg/m^2).[18]

- Biochemical analysis - two hours after the first meal of the day, two blood samples were collected from one of the upper limb of each senior, at rest (B) and in the sixth minute after acute exercise (6), for the determination of glucose and lipid control (GPP, TG, TC, LDL-C, VLDL-C and HDL-C). The samples were identified and placed in sterile test tubes, and subsequently analyzed with the enzymatic method. Serum was obtained by centrifugation at 5000 rotations per minute (rpm) for 10 minutes and biochemical analyzes performed with specific laboratory kits.

- Cardiorespiratory performance assessment with ergospirometry test - done by trained cardiologist for measuring peak oxygen consumption (VO_{2peak} ml/kg/min); time, in seconds, to reach the peak oxygen consumption (TVO_{2peak}); carbon dioxide production (VCO_2 l/min); carbon dioxide ventilatory equivalent (VE/VCO_2 l/min) and respiratory exchange ratio (R) with the patient's usual medication. The test was performed on a Micromed Centrium 300 treadmill, made in Brazil, with the ErgoPC Elite® software connected to a Micromed electrocardiograph with 11 channels, made in Brazil, and a Cortex Metamax 3B ergospirometer, made in Leipzig, Germany. The exercise room had proper temperature and humidity and counted with emergency equipment to prevent/treat any complications. Each individual being evaluated received recommendations and general orientation regarding the exam and was introduced to the equipment.[12,13] The protocol off choice was the ramp increment,[19] with measurements of dyspnea, blood pressure, oxygen saturation and ECG leads every two minutes. The test was terminated when the subject presented electrocardiographic changes at rest, exercise or requested interruption of effort, even if the thresholds had not been achieved. The values were captured breath by breath, under standard conditions of temperature, pressure, and humidity (StPD), at the moment of maximum effort and at the first ventilatory threshold.

- Blood pressure measurement by the indirect method, with auscultatory technique and aneroid sphygmomanometer. The elder was sitting, at rest, during the systolic and diastolic baseline blood pressure measurement (SBP mmHg and DBP mmHg). The systolic and diastolic blood pressures were also measured during the ergospirometry recovery period in the first and sixth minutes after the test.

Statistical Analysis

The sample was characterized by descriptive analysis. The tests applied were Kolmogorov-Smirnov for normality and Mann-Whitney and Wilcoxon for intragroup and intergroup associations, respectively. A Spearman's nonparametric correlation study was conducted in order to verify the interaction between the ergoespirometric, biochemical, and pressoric variables. Multiple Linear Regression was performed to predict TVO_{2peak} and VE/VCO_2, testing as predictors the variables with significant linear correlations. Backward model was used with entry criteria for P=0.05 and removal criteria for P=0.10. It was considered as the final model the one which p referring to the change of F with ANOVA was significant. The results are presented in tables and figure. The statistical analysis was performed using the SPSS software (Statistical Package for the Social Sciences), version 15.0. A value of $p < 0.05$ was considered significant.

RESULTS

Sample general characterization and intergroup association:

Table 1 characterizes the total sample and compares the groups (G1 and G2) by age, BMI, VO_{2peak}, TVO_{2peak}, VCO_2, VE/VCO_2, basal and after acute exercise blood pressure, glucose, and lipid levels, demonstrating comparability between groups, except in the PPG_B, VO_{2peak}, TV_{O2peak} and VCO_2 variables. G2 had higher basal glucose level and lower results in the ergoespiromety variables. Most subjects in both groups were overweight.

Intragroup associations of the lipid variables before and after maximal exercise test:

Regarding the acute effect of maximal exercise test, the whole lipid profile increased both in G1 and in G2. The significance level was higher in G2, in the TG and VLDL-C variables. However, these significant changes observed in the lipid profile of each group did not reflect in post-exercise intergroup differences (Table 2).

Correlations of ergoespirometry, lipid, and blood pressure variables:

G1 has not shown significant differences in the correlation of ergoespirometry, lipid, and blood pressure variables. On the other hand, G2 has shown negative correlations of LDL-CB (p= 0.010) and LDL-C_6 (p=0.011), DBP_B (p=0.015), DBP_6 (p=0.010) with TVO_{2peak}. G2 has also shown positive correlations of TG_B (p=0.028), TG_6 (p=0.030), VLDL-C_B (p=0.027), VLDL-C_6 (p=0.031), DPB_6 (p=0.017) with VE/VCO_2 slope as well as negative correlations with HDL-C_B (p=0.002) and HDL-C_6 (p=0.003) with the same ergospirometry variable (Table 3).

Multiple linear regression analysis:

The linear regression analysis VE/VCO_2 prediction, showed that HDL-$C_{B,}$ VLDL-C_B and TG_B produced multiple R of 0.687 witn adjusted R^2 of 37.3% (model 1), indicating a moderate correlation between observed and predicted values (ANOVA, p=0.015) (Table 4). The HDL-C_B, VLDL-C_B and TG_B standardized ß coefficients were -0.529 (p=0.031), -11.113 (p=0.227) and 11.295 (p=0.270), respectively, suggesting that HDL-C_B is significantly more relevant than VLDL-C_B and TG_B in predicting VE/VCO_2.

DISCUSSION

The hypertensive diabetic elderly had a poorer cardiorespiratory performance during ergospirometry. In this group only the shorter time to reach VO_{2peak} was correlated with high levels of LDL-C. Also, the increased VE/VCO_2 curve was correlated with high plasma concentrations of TG and VLDL-C and low plasma concentrations of HDL-C. Notwithstanding, LDL and HDL cholesterol fractions were identified as the major predictors of the poor performance of these subjects. These findings are consistent with acute effects after performing an exhaustive exercise of short duration

The cardiorespiratory performance of the elderly in this study, regardless the group they belonged to, was lower than that observed by Herdy and Uhlendorf,[20] who investigated healthy and sedentary elderly people. Such reduction can be explained by the presence of the comorbidities hypertension and hypertension associated with diabetes in the sample studied. This assumption has already been pointed out by Jackson et al.[8] who stated that cardiorespiratory performance decreases with aging and is associated with chronic diseases, which can be enhanced by overweight.[21]

The comparative evaluation between G1 and G2 showed that the cardiorespiratory performance was markedly compromised in G2. The hypertensive diabetic elderly, when submitted to maximum stress, consumed less O_2, decreased CO_2 production, produced less energy, thus presenting sooner signs of fatigue.

Studies have proved that T2DM can affect physical performance in the elderly through several mechanisms. Clinically, the diabetic elderly have poorer muscle quality compared with non-diabetics. They lose muscle quality and strength more quickly, especially those whose disease is longer, have worse glucose control and are insulin sensitive.[22,23]

The hyperglycemia-induced chronic inflammation state exerts adverse impact on the skeletal muscle function.[24] Besides, the non-enzymatic glycosylation modifies myosin and actin structures and functions,[25] which, added to TG accumulation,[26] interferes with muscle contraction.

Although there was a significant increase in all lipid profile immediately after the test in both groups, the raise of TG and VLDL-C plasma levels were more significant for G2. Lemos et al.,[14] when using an animal model of T2DM, have not found significant values in TC and TG levels as an acute effect of strenuous exercise.

However, other studies indicate that insulin resistance in skeletal muscle promotes the conversion of energy into increased TG synthesis, which, in turn, generates a large number of TG-rich atherogenic particles, such as VLDL-C.[2,4]

The VLDL-C function in the body is the internal transport of TG, and when present in the blood stream, it is converted into LDL-C. In T2DM, since TG plasma levels exceed 100 mg/dl, LDL-C particles become smaller and denser through the hydrolysis action of hepatic TG.[27]

Regarding LDL-C levels, in general, they are not higher in diabetic people than in those without the disease,[28] a fact confirmed by this study. But, a large number of small, dense particles characterize the LDL-C fraction in diabetic subjects. These particles contain less cholesterol than normal sized

LDL particles, but they are exceptionally atherogenic because they are more readily oxidized and glycosylated, making them more likely to invade the arterial wall.[1,3,29]

The association between the increase of LDL-C small dense particles and insulin resistance common in T2DM may initiate atherosclerosis, or lead to increased migration and apoptosis of vascular smooth muscle cells in existing atherosclerotic lesions.[2,29]

In the present research, the LDL-C level in hypertensive diabetic seniors proved to be in 55.9% able to contribute to TVO_{2peak} decrease. This variable correlates with aerobic performance. The shorter time to reach VO_{2peak} shows early fatigue. Nesto[27], in a literature review, confirms that LDL-C in normal or high level can be more pathogenic in diabetic people, causing vascular changes, increased cardiovascular risk, and consequently, decreased cardiorespiratory performance.

The increase in the VE/VCO_2 slope is related to the decrease of lung perfusion capacity and the cardiac output, indicating greater morbidity and a worse cardiorespiratory prognosis.[30] Although one of the exclusion criteria of this research was a VE/VCO_2 value greater than 34, the comparison of G1 and G2 values has not shown significance. Only the hypertensive diabetic group showed correlation and VE/VCO_2 linear relation with the circulating level of TG, VLDL-C and HDL-C, the latter variable being the most important predictor.

The possible triggering mechanisms of the low cardiorespiratory performance in G2 related to TG, VLDL-C, and LDL-C have already been discussed in this study. However, HDL-C, which is considered an antiatherogenic lipoprotein, seems to promote cardioprotective benefits in the diabetic elderly. This lipoprotein was inversely correlated with VE/VCO_2, and was predictive of the same ergospirometry variable with multiple R of 0.64 and adjusted R^2 of 37.6%.

T2DM is a powerful independent risk factor for heart failure. Mechanisms directly related to diabetes that affect cardiac function must be identified and studied.[31] One of the mechanisms by which HDL-C exerts a protective effect on the development of atherosclerosis is the reverse cholesterol transport, in which the lipoprotein performs the efflux of excess cellular cholesterol from peripheral tissues and its return to the liver.[32,33] However, Besler et al.[34] state that the

HDL-C biological functions, that is, the endothelium atheroprotective effects, are very heterogeneous and are altered in patients with heart disease or diabetes.

More data on the metabolic response to acute exercise are needed. However, what has been considered in this study is that the increased levels of TG, VLDL-C and LDL-C in T2DM elderly patients are more atherogenic and potentiate low cardiorespiratory performance, regardless the hypertension, overweight, and sedentariness found in the entire sample surveyed. Moreover, the HDL-C also increased after exercise and its higher baseline level showed a cardioprotective effect.

Given the research that has been conducted and the results found in this study, it is advisable that higher intensity exercise for the diabetic, hypertensive, sedentary, elderly population is performed with continuous monitoring of hemodynamic and metabolic variables.

Acknowledgments

We thank the staff of the Laboratory of the Amaury de Medeiros Integrated Health Center – University of Pernambuco (CISAM/UPE), by determining the biochemical variables.

Disclosure Statement

None of the authors have conflicts of interest.

Financial support: Fundação de Amparo à Ciência e Tecnologia de Pernambuco (FACEPE), CNPq and CAPES.

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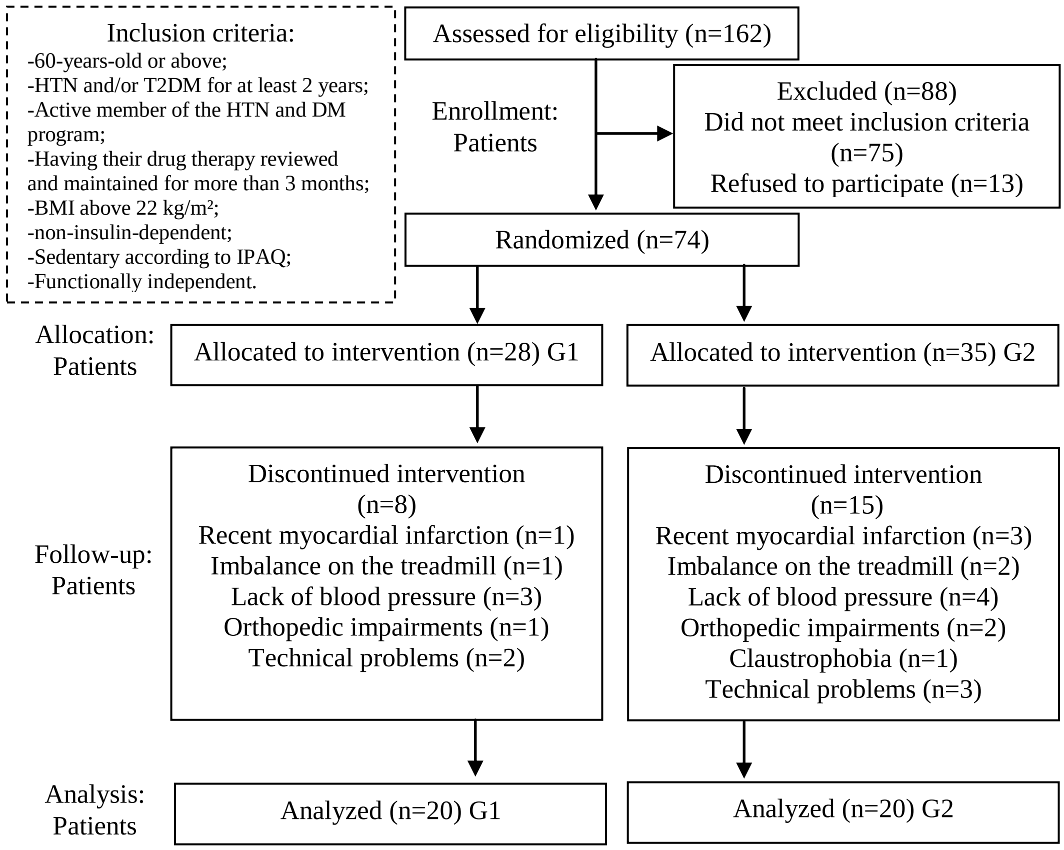

Figure 1. Schematic of subject flow and reasons for exclusion.

Table 1. Total sample characterization and comparison of pre-exercise anthropometric, blood pressure, glucose, and lipid variables and also intergroups ergoespirometry data.

	Total Sample	Groups		
		G1	G2	
	(n=40)	(n=20)	(n=20)	
Variables	Mean ± sd	Mean ± sd	Mean ± sd	p
Pre-exercise				
Age (years)	68.73 ±6.26	68.50 ±5.85	68.95 ±6.79	ns
BMI (kg/m²)	29.59 ±4.41	28.94 ±4.26	30.24 ±4.57	ns
SBP (mmHg)	128.75 ±13.34	126.75 ±12.59	130.75 ±14.07	ns
DBP (mmHg)	82.00 ±5.52	82.00 ±5.23	82.00 ±5.94	ns
PPG (mg/dL)	107.63 ±56.46	84.10 ±22.92	131.15 ±69.66	0.013(*)
TG (mg/dL)	184.48 ±96.22	199.55 ±114.30	169.40 ±73.92	ns
TC (mg/dL)	200.60 ±48.36	208.75 ±49.60	192.45 ±46.91	ns
HDL-C (mg/dL)	52.10 ±16.23	51.70 ±14.30	52.50 ±18.32	ns
LDL-C (mg/dL)	111.43 ±39.91	117.15 ±43.33	105.70 ±36.38	ns
VLDL-C (mg/dL)	41.85 ±20.76	43.20 ±23.35	40.50 ±18.31	ns
Ergospirometric				
VO_{2peak} (ml/kg/min)	17.56 ±3.74	19.70 ±3.44	15.42 ±2.71	<0.0001(**)
TVO_{2peak} (sec)	408.10 ±145.59	470.70 ±148.03	345.50 ±115.51	0.005(**)
VCO_2 (ml/kg/min)	19.71 ±4.42	21.91 ±4.49	17.52 ±3.13	0.003(**)
VE/VCO_2 (ml/kg/min)	28.24 ±2.90	27.44 ±2.47	29.01 ±3.14	ns

BMI (body mass index); SBP (systolic blood pressure; DBP (diastolic blood pressure); PPG (postprandial glucose; TG (serum triglycerides); TC (serum total cholesterol); HDL-C (high density lipoprotein-cholesterol); LDL-C (low density lipoprotein-cholesterol); VLDL-C (very low density lipoprotein-cholesterol); VO_{2peak} (oxygen uptake at peak exercise); T VO_{2peak} (time to reach oxygen uptake at peak exercise); VCO_2 (carbon dioxide output); VE/VCO_2 (ventilatory equivalent for carbon dioxide). Mann-Whitney Test. (**) p≤0.01. (*) p<0.05. ns (not significant).

Table 2. Analysis of lipid variables before and after maximal exercise test in G1 and G2, compared with intergroup post-exercise.

	G1			G2			G1 and G2
	Pre-exercise	Post-exercise		Pre-exercise	Post-exercise		Post-exercise
Variables	Mean ±sd	Mean ±sd	p intragroups	Mean ±sd	Mean ±sd	p intragroups	p intergroups
TG (mg/dL)	199.55 ±114.30	214.95 ±117.15	0.048(*)	169.40 ±73.91	202.40 ±91.33	<0.0001(**)	ns
TC (mg/dL)	208.75 ±49.60	222.35 ±49.24	<0.0001(**)	192.45 ±46.91	205.80 ±50.59	0.001(**)	ns
HDL-C (mg/dL)	51.70 ±14.30	61.00 ±30.23	0.003(**)	52.50 ±18.32	55.45 ±18.89	0.003(**)	ns
LDL-C (mg/dL)	117.15 ±43.33	118.10 ±46.91	0.009(**)	105.70 ±36.38	110.05 ±39.60	0.016(*)	ns
VLDL-C (mg/dL)	39.95 ±22.88	43.20 ±23.35	0.048(*)	33.90 ±14.74	40.50 ±18.31	<0.0001(**)	ns

TG (serum triglycerides); TC (serum total cholesterol); HDL-C (high density lipoprotein-cholesterol); LDL-C (low density lipoprotein-cholesterol); VLDL-C (very low density lipoprotein-cholesterol). Mann-Whitney and Wilcoxon Tests. (**) $p<0.01$. (*) $p<0.05$. ns (not significant).

Table 3. Correlations between the ergoespirometry and biochemical variables.

	Ergospirometric Variables			
	TVO_{2peak}		VE/VCO_2	
	G1	G2	G1	G2
Biochemical Variables	*rho*	*rho*	*rho*	*Rho*
TG_B (mg/dL)	-0.186 ns	-0.165 ns	0.158 ns	0.491 (*)
TG_6 (mg/dL)	-0.155 ns	-0.064 ns	0.154 ns	0.485 (*)
$HDL\text{-}C_B$ (mg/dL)	0.234 ns	0.107 ns	-0.168 ns	-0.640 (**)
$HDL\text{-}C_6$ (mg/dL)	0.075 ns	0.110 ns	0.080 ns	-0.627 (**)
$LDL\text{-}C_B$ (mg/dL)	-0.088 ns	-0.559 (*)	0.054 ns	0.118 ns
$LDL\text{-}C_6$ (mg/dL)	-0.020 ns	-0.555 (*)	-0.079 ns	0.148 ns
$VLDL\text{-}C_B$ (mg/dL)	-0.188 ns	-0.166 ns	0.155 ns	0.495 (*)
$VLDL\text{-}C_6$ (mg/dL)	-0.162 ns	-0.069 ns	0.159 ns	0.482 (*)

TG_B (serum triglycerides – basal); TG_6 (serum triglycerides – 6^{th} minute); $HDL\text{-}C_B$ (high density lipoprotein-cholesterol – basal); $HDL\text{-}C_6$ (high density lipoprotein-cholesterol – 6^{th} minute); $LDL\text{-}C_B$ (low density lipoprotein-cholesterol – basal); $LDL\text{-}C_6$ (low density lipoprotein-cholesterol – 6^{th} minute); $VLDL\text{-}C_B$ (very low density lipoprotein-cholesterol – basal); $VLDL\text{-}C_6$ (very low density lipoprotein-cholesterol – 6^{th} minute). Spearman's Correlations (rho). (**) p<0.01. (*) p<0.05. ns (not significant).

Table 4. Results of multiple linear regression analysis.

					Change Statistics		ANOVA
Model	Predictors	R	R^2	R^2 Adjusted	R^2	Sig. F	p
	VE/VCO_2						
1	$HDL\text{-}C_B$, $VLDL\text{-}C_B$, TG_B	0.687	0.472	0.373	0.472	0.015	0.015 (*)
2	$HDL\text{-}C_B$, $VLDL\text{-}C_B$	0.656	0.431	0.364	-0.042	0.277	0.008 (**)
3	$HDL\text{-}C_B$	0.640	0.409	0.376	-0.022	0.433	0.002 (**)

Dependent Variable: VE/VCO_2 (ventilatory equivalent for carbon dioxide). Predictors: $LDL\text{-}C_B$ (low density lipoprotein-cholesterol – basal), $HDL\text{-}C_B$ (high density lipoprotein-cholesterol – basal), $VLDL\text{-}C_B$ (very low density lipoprotein-cholesterol – basal), TG_B (serum triglycerides – basal), DBP_B (diastolic blood pressure – basal). (**) p≤0.01, (*) p<0.05.

8. CONSIDERAÇÕES FINAIS

A hipótese investigada neste estudo foi confirmada, à medida que se verificou a associação entre sintomas depressivos, declínio funcional, dislipidemia e redução da atividade física nos idosos diabéticos. Adicionalmente, esses fatores constituíram-se preditores da ocorrência dos sintomas depressivos no grupo amostral investigado.

Esses dados reforçam a importância quanto à identificação precoce do declínio funcional e do sedentarismo por meio do uso de instrumentos acessíveis e de fácil aplicação, juntamente com a detecção de alterações dos níveis de HDL-C e LDL-C, diagnosticada em um simples exame laboratorial, em idosos diabéticos, antes mesmo do surgimento de outras comorbidades que relacionam o DM2 à depressão, como dependência nas AVD, déficit cognitivo, imobilidade, doenças cardiovasculares e amputações.

Quanto à influência do DM2 no desempenho cardiorrespiratório de idosos hipertensos e sedentários, constatou-se que as respostas cardiorrespiratórias decorrentes do teste ergoespirométrico nos hipertensos e hipertensos com DM2 foram diferentes, de modo que a associação HAS-DM2 produziu menor eficiência cardiorrespiratória, mesmo na ausência de cardiopatia. Tal achado tem aplicabilidade clínica, uma vez que os hipertensos e diabéticos constituíram-se como um grupo populacional, que apresenta maior fadiga aguda, induzida pelo exercício com alteração imediata no perfil metabólico.

A associação entre HAS e DM2 deve ser uma condição clínica a ser verificada pelos cardiologistas, geriatras, clínicos, gerontologistas, fisiologistas do exercício e fisioterapeutas durante a prescrição, execução, acompanhamento de exercícios físicos e nos programas de reabilitação cardiovascular, cujas metas de frequência cardíaca de treino devem estar, a princípio, abaixo do primeiro limiar anaeróbico.

Dentre todos os fatores estudados, os mais altos níveis de pressão arterial diastólica (PAD) e LDL-C assim como os mais baixos de HDL-C demonstraram ser preditores do pior desempenho cardiorrespiratório em idosos diabéticos e hipertensos, fortalecendo, ainda mais, a continuidade no sedentarismo.

A pior capacidade ao esforço físico dos idosos diabéticos não cardiopatas aponta a necessidade de um novo olhar por parte dos profissionais de saúde para essa fração da população que apresenta maior morbidade cardiovascular, merecendo maior atenção propedêutica e terapêutica.

Novas estratégias para incentivar a prática da atividade física regular, a partir de intensidades leve e moderada, podem prevenir o surgimento dos sintomas depressivos, retardar a progressão do declínio funcional, controlar a dislipidemia e melhorar a capacidade cardiorrespiratória dessa população.

O desafio em relação à inserção, de forma adequada, da atividade física no cotidiano do idoso diabético e sedentário está lançado para os profissionais de saúde e para as autoridades governamentais. Faz-se necessário um incremento no tocante aos estudos que utilizem ensaios clínicos controlados e randomizados com *follow-up* buscando esclarecer o envolvimento entre LDL-C, HDL-C, depressão, PAD, desempenhos funcional e cardiorrespiratório em idosos com DM2.

APÊNDICE 1 – ARTIGO A

Falls, Physical Activity, Ankle Flexibility and Balance Assessment of Functionally Independent Elderly Women

Avaliação de Quedas, Flexibilidade do Tornozelo e Equilíbrio em Idosas Independentes Funcionalmente

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Journal of Aging and Physical Activity

Falls, Physical Activity, Ankle Flexibility and Balance Assessment of Functionally Independent Elderly Women

Journal:	*Journal of Aging and Physical Activity*
Manuscript ID:	JAPA_2012_0296
Manuscript Type:	Original research
Focus Area:	balance gait fall prevention, physical fitness
Statistical Methods:	t-Tests, unpaired < t-Tests, Other
Free-Form Keywords:	elderly women, falls, ankle range of motion, postural balance, sedentariness

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Falls, Physical Activity, Ankle Flexibility and Balance Assessment of Functionally Independent Elderly Women

Abstract

The aim of this study was to evaluate falls and risk factors in functionally independent elderly women (n=80). Evaluation: investigation of falls, fear of falling and regular physical activity in the previous year, as well as ankle flexibility and static and dynamic postural balance. The subjects had a high frequency of falls (77.5%), which occurred mostly in the street (69.4%), in the morning (46.8%), and having as the main cause the lack of maintenance of sidewalks and roads (43.6%). The fall event was associated with physical inactivity ($p<0.05$), and when recurrent, with decreased ankle flexibility ($p<0.05$) and imbalance ($p<0.01$). There is an important involvement of extrinsic factors due to the lack of environmental safety. As for intrinsic and behavioral factors, the limited balance control of the subjects associated with decreased ankle flexibility and sedentariness result in low postural stability, which leads to falls, especially the recurrent ones.

Keywords: elderly women, falls, ankle range of motion, postural balance, sedentariness

Introduction

The proportional increase of the elderly population is a universal phenomenon. Brazil has been following this trend, being always a little above the world mean. The annual growth of the elderly population in the 21st century will continue, and it will be higher among women (Carvalho & Rodríguez-Wong, 2008).

Factors that favor muscle shortening, weakness, and decreasing range of motion are added to the aging process associated to physical inactivity. This condition contributes to the reduction of flexibility as well as postural and dynamic balance, important elements in the prevention of falls and fractures (Menz, Morris, & Lord, 2006; Faulkner, Larkin, Claflin, & Brooks, 2007; Tinetti *et al.,* 2008).

Falls are the leading cause of accidental death, mainly among the elderly, being women the most prone to fall, especially when walking (Fleming, Fiona, Matthews, & Brayne, 2008, Bleijlevens *et al.,* 2010; Mertz, Lee, Sui, Powell, & Blair, 2010). The etiology of falls is multifactorial. The intrinsic factors are the physiological changes resulting from aging and their multiple associated pathologies. The extrinsic factors are related to environmental and external risks. The behavioral factors are associated with lifestyle (Berry & Miller, 2008; Kojima, Furuna, Ikeda, Nakamura, & Sawada, 2008; Faulkner *et al.,* 2009; Lai, Low, Wong, Wong, & Chan, 2009).

Considering that the identification of the extrinsic, intrinsic, and behavioral factors may change and correct some of them, and that this can significantly reduce the risk of falls, this study aims to describe falls and risk factors in community-dwelling functionally independent elderly women.

Methods

Participants

The initial sample consisted of 120 women enrolled in six Fall Prevention Workshops (FPW) offered by the program for a year. The eligibility criteria consisted of participation in the FPW, aged 60 or over, female, walking without assistive devices, and functional independence, according to a geriatric assessment in their medical records. Eighty women were selected for the study with mean age of 68.70 ± 5.89 years, representing 66.7% of the initial sample.

Design and Procedures

Cross-sectional study developed in an elderly care program sponsored by a Brazilian university and approved by The Institutional Committee for Ethics in Research. All participants were informed about the study characteristics and agreed to participate voluntarily, signing an informed consent.

The geriatric assessment protocol of the university's elderly care program was adapted for the research. The study was divided into two distinct phases and developed by the procedures described below.

In the first phase, the participants filled in a semi-structured questionnaire for the investigation of falls, fear of falling and the practice of regular physical activity. The instrument asked about the frequency, place, and time (part of the day) of falls in the previous year, intrinsic and extrinsic factors, sequelae related to the last fall, fear of falling, and the types of physical activity practiced regularly. Only the activities performed at least three times a week for 30 minutes or more were considered. Between the first and second stages of the research there was a drop-out of 20%.

In the second phase of the research two evaluations of functional mobility were carried out.

1st – Ankle's range of motion: assessed by goniometry of the talo-crural joint by two trained researchers, who used a clinical goniometer. Measurements were taken with active-assisted movements (Thoms & Rome, 1997). The dorsiflexion and plantar flexion range of motions were measured bilaterally. The full range of motion, assessed as ankle flexibility, was obtained by adding the mean measurements of the dorsiflexion and plantar flexion.

2nd - Static and dynamic postural balance: Fifteen balance-related motor tasks (MT) were selected and adapted from the Balance and Coordination Test (Schmitz, 2004). The tasks were the following: stand still for 10 seconds in different stances (with feet together, with one foot in front of the other, on one foot only, forward bend, lateral bend, and forward displacement of center of gravity); different kinds of gaits (in place, forward, sideways, backwards, with increased speed, stop and restart of gait, 360 degrees turning, on heels, on tiptoes). The following score was applied for each task: 2 points (no difficulty, normal performance), 1 point (some difficulty in the activity with arrhythmic movements, instability and/or large oscillations), 0 point (unable to perform the activity), with a maximum total score of 30 points.

Assessing the results, the sample (n = 80) was divided initially into two groups:

G1 (women with no history of falls, and mean age of 68.83 ±5.17 years);

G2 (women who had suffered at least one fall in the previous year, with mean age of 68.66 ±6.13 years). Then, for the analysis of falls, G2 was subdivided into G2SF (women who had suffered a single fall) and G2RF (women who had suffered more than a fall, recurrent falls).

Statistical Analysis

Descriptive analysis was used to characterize the sample. The statistical analysis was performed using the software SPSS (Statistical Package for the Social Sciences), Version 15.0. All tests were applied with 95% confidence, and statistical significance level was set at $p<.05$. The tests applied were Kolmogorov-Smirnov Normality Tests, Chi-Square, Fisher's Exact and Student's t. The results are presented in tables.

Results

Among the 80 women who participated in the study, 77.5% had falls in the previous 12 months, being 33.8% of them recurrent falls, 69.4% fell in the street, 46.8% of the falls occurred in the morning, 68.7% were caused by extrinsic factors and 62.5% of the subjects reported having sequelae after the event. Among the extrinsic factors, 43.6% were sidewalks or streets with holes (uneven ground). For the intrinsic factors, imbalance was referred by 50.0% of the subjects. With regard to fall sequelae, 40.0% were abrasions and 66.0% were in the lower limbs (Table 1). Fear of falling was reported by 72.5% of the subjects.

When filling in the questionnaire related to physical activity, 68.7% of the total sample referred practicing one or more activities. But Table 2 shows that sedentary behavior was present in 11.1% of G1, 38.7% of G2 ($p = .043$), 34.3% of G2SF, and 44.4% of G2RF ($p = .034$). Walking was the most frequent activity: G1 (76.5%), G2 (50.0%), G2SF (54.3%) and G2RF (44.4%). Regarding the practice of yoga, 29.4% belonged to G1 and 6.5% to G2. Only yoga was a significant difference between G1 and G2 ($p = .007$).

Table 3 shows that G1 and G2 showed no difference in the evaluations of ankle flexibility and balance performance. There was, however, a difference in G2SF and G2RF regarding ankle flexibility ($p = .031$) and balance performance ($p = .004$), indicating less flexibility and poor balance for the group of women who had fallen more than once (G2RF).

Table 4 indicates that the elderly women who reported a greater number of falls (G2RF) had more difficulties, that is, lower scores in motor tasks of the balance test, forward displacement of the center of gravity ($p = .001$), stop and restart of gait ($p = .037$), walking on heels ($p = .039$) and walking on tiptoes ($p = .004$).

Discussion

The results of this study indicate that the functionally independent elderly women had a high frequency of falls, which occurred mostly in the street, in the morning, and having as the main cause the lack of maintenance of sidewalks and roads. Moreover, the falls were associated with sedentariness, and when recurrent, with ankle decreased flexibility and poor balance, especially in dynamic postures that required a greater shift in the center of gravity and a greater ankle range of motion.

Studies on fall prevalence in the elderly indicate that over one third of community-dwellers fall annually and approximately half of them had more than a fall in the period (Fleming *et al.,* 2008; Kojima *et al.,* 2008).

The frequency of falls reported by this study was high (77.5%) compared to those reported in the above mentioned studies. This high frequency is probably related to the type of cross-sectional study with convenience sample, women seeking FPW. The results confirm the research of Moore et al. (2010) who evaluated 43 elderly women from a fall prevention clinic in Seattle, and reported that 97.7% of them had had at least one fall in the previous year.

The present study shows that 33.8% of the subjects had recurrent falls (two or more) and 72.5% reported fear of falling. These data bring us close to the statistics related to the increasing number of falls among the elderly and the fear of falling again, particularly among women. According to Kempen, van Haastregt, McKee, Delbaere, & Zijlstra (2009), victims of recurrent falls, mainly elderly women, limit their activities of daily living, walk less at home and have more trouble going out. These facts increase the co-morbidities and are considered predictive factors for further falls, which aggravate and accelerate the effects of aging. Hill, Womer, Russell, Blackberry, & McGann (2010) when presenting a report on the fear of falling in 712 elderly people who sought an emergency service after a fall, reported that 60% were afraid of falling again and 70% were women.

Probably for being community-dwellers active older women, the research indicated that 46.8% of the falls occurred in the morning and 37.2% in the afternoon, corroborating the conclusion of other studies in which the majority of falls in functionally independent elderly women occurs at times of maximum activity during the day and while walking (Bleijlevens et al., 2010, Mertz et al., 2010).

Associated with all these facts, the extrinsic causes, environmental conditions experienced by the elderly, were the ones that most caused falls (68.7%), and among them, 43.6% occurred due to holes in the streets, in accordance with Kojima et al. (2008) and Faulkner et al. (2009), who stated that extrinsic factors, especially the environmental ones, are responsible for most of the falls in the community-dwelling elderly. This contributes to corroborate the study by Lai et al. (2009), where elderly women fell outside their homes, being therefore, the external environment the most representative site.

Gama & Gómez-Conesa (2008) in a systematic review concluded that there is a lack of epidemiological prospective cohort studies on the multiple risk factors of falls among the elderly, as well as their extrinsic determinants. The authors state that cross-sectional studies may be useful for further analysis of falls.

Although the extrinsic factors caused most of the falls, the intrinsic factors, which are related to the subjects themselves, emerged as 22.5% as the factors responsible for the falls. Among them, imbalance was the most cited by the subjects. The decrease of agility and dynamic balance along the aging process increase the risk of falls. When these falls result from a complex interaction of intrinsic and extrinsic factors, they should be studied in more detail in order to assess the possibility of prevention of potentially reversible factors. Such factors are often related to high rates of falls and sequelae among the community-dwelling elderly, as stated by Tinetti et al. (2008).

There were four types of sequelae resulting from the last fall: abrasions, pain, bruises, and fractures. 75.8% of the subjects reported having experienced at least one of them, being the lower limbs the most affected. Fractures occurred in a higher percentage than that reported in the study of Berry & Miller (2008), possibly because it is an elderly female population, which suggests the presence of osteoporosis following the musculoskeletal changes related to menopause. Ojo, O'Connor, Kim, Ciardiello, & Bonadies (2009) observed that the majority of falls in the active and independent elderly does not result in serious injury, but the potential for morbidity is a reality.

Although 68.7% of the subjects practiced some kind of physical activity, it seems that this fact alone did not prevent falls, since the frequency was high. But in splitting up the groups, sedentariness was more significantly present in G2 (38.7%) and G2RF (44.4%). Meisner, Dogra, Logan, Baker, & Weir (2010) say that sedentary behavior when present in the elderly is strongly associated with functional limitations, while regular physical activity, even at moderate levels, optimizes biopsychosocial and functional health, contributing to successful aging. Physical inactivity increases the risk of non-communicable chronic diseases, and in the elderly, can lead to the development of syndromes considered geriatric: postural instability and immobility (Inouye, Studenski, Tinetti, & Kuchel, 2007).

Petridou, Manti, Ntinapogias, Negri, & Szczerbinska (2009) highlight the importance of implementing regular physical activity for sedentary older women in order to improve muscle performance, mobility, functional capacity, flexibility and balance, thus reducing the risk of falling. Peeters, van Schoor, Pluijm, Deeg, & Lips (2010) suggest that the increase of physical activity can reduce the risk of recurrent falls. But Horne, Speed, Skelton, & Todd (2009) state that the younger and independent elderly do not recognize their risk of falling and usually do not feel motivated to exercise in order to avoid falls. Laforest et al. (2009) report that fall prevention programs that include balance exercises and educational components have the potential to encourage continuous involvement of the community-dwelling elderly in physical activity, modifying sedentary behavior.

Among the physical activities mentioned by the subjects, walking was the most performed, but yoga was the one that showed significant difference between G1 and G2, demonstrating that it contributes to the prevention of falls in people who practice it.

Although in this research walking has not been presented as a fall prevention activity, it has been widely accepted by the elderly. However, yoga has been referred by researchers as a good physical activity for the prevention of falls in the elderly because it significantly improves gait performance, dynamic postural control through muscle stretching and strengthening, and flexibility, allowing an excellent response to somatosensory stimuli, which can be very helpful in maintaining proper balance in daily life (Schmid, van Puymbroeck, & Koceja, 2010).

The results of a systematic review published by Arnold, Sran, & Harrison (2008) suggest that physical exercise, performed in groups, individually or a combination of both, can reduce the number of falls as well as the fall risk in the elderly. The authors found out that both long-term and short-term exercise programs are effective in reducing the risk of falling, which was assessed by different instruments.

The physical assessment conducted by the researchers of this study showed a decrease in ankle flexibility, being it significantly higher in the elderly who had recurrent falls (G2RF). Corroborating these findings, Menz et al. (2006) significantly related postural instability to limited movement of the ankle among older adults. The reduction of the ankle's range of motion increases the risk of falls by changing movement patterns, which compromises balance, leading to falls after displacements and limiting functional activities such as walking.

The subjects did not differ in the balance total score when comparing groups G1 and G2, but when G2SF and G2RF were compared, those who suffered recurrent falls had lower total score. When the balance test motor tasks were compared separately in the presence of falls in the subgroups G2SF and G2RF, the subjects with recurrent falls presented greater difficulty in performing the movements of shifting the center of gravity forward, stopping and restarting gait, walking on heels and tiptoes, being these two last tasks dependent on ankle flexibility.

The aging process brings functional changes in the nervous, sensory and musculoskeletal systems affecting several motor activities, which are suggested as predictors of falls. In the elderly who already reflect the effects of aging on motor control, there are a variety of compensatory mechanisms, such as broadening the base of support, as attempt to maintain proper upright position and functional gait (Faulkner *et al.,* 2007).

Likewise this research, Bhatt, Wening, & Pai (2005) reported that activities that move the center of gravity away from the base of support lead to compensatory reactions and can cause recurrent falls. Holbein-Jenny, McDermott, Shaw, & Demchak (2007) associated aging with decreasing stability, that is, the individual's ability to intentionally shift their center of gravity and body in a certain direction without losing balance. Oka et al. (2006) found that elderly women had balance changes more often than men, especially during a destabilization of the center of gravity and when tiptoeing to reach an object. Laessoe & Voigt (2008) reported that older people use anticipatory postural control strategies to minimize the impact of predictable disturbances, but this control seems to be less automated in this population and it becomes deficient during more challenging disturbances.

This study leads us to consider that in addition to factors related to the aging process of community-dwelling functionally independent elderly women, the extrinsic factors play an important role with the lack of environmental safety. Among them, we highlight the poor condition of streets and sidewalks associating, in most cases, the occurrence of falls outdoors with stumbles on sidewalks or holes in the streets.

We consider that the elderly limited balance associated with ankle decreased flexibility and a sedentary lifestyle, seen as intrinsic and behavioral factors in this study, influence postural stability and explain the falls, especially the recurrent ones.

These findings suggest the need for preventive and rehabilitative interventions that can contribute to minimize the impact of such neuromusculoskeletal changes on the risk of falls of this population.

The information presented in this research should give the foundation for policy and procedure makers in the health care field to reflect on the needs of this age group while working on the organization of health services and environmental planning. The increase in the number and severity of falls in the elderly not only causes functional decline and poor quality of life, but also possible hospitalizations and rise in medical and hospital costs.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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Table 1

Characterization of falls suffered by elderly women

Variables	n	%
Number of falls		
0	18	22.5
1	35	43.7
≥ 2	27	33.8
Place of last fall		
Street	43	69.4
Home	16	25.8
Others	3	4.8
Time of last fall		
Morning	29	46.7
Afternoon	23	37.1
Evening	10	16.2
Extrinsic factors	55	68.7
Sidewalks or streets with holes	24	43.6
Slippery floor	15	27.3
Inappropriate shoes	10	18.2
Steps	7	12.7
Others	7	12.7
Intrinsic factors	18	22.5
Imbalance	9	50.0
Dizziness	3	16.6
Weak legs	3	16.6
Others	3	16.6
Sequelae after the fall	50	62.5
Abrasions	20	40.0
Bruises	9	18.0
Fractures	7	14.0
Pain	7	14.0
Body parts with sequelae	50	62.5
Lower limbs	33	66.0
Upper limbs	9	18.0
Trunk	9	18.0
Head	2	4.0

Table 2

Sedentary behavior and types of physical activities performed by elderly women

	G1		G2			G2SF		G2RF		
Variables	n	%	n	%	p	n	%	n	%	p
Sedentariness	2	11.1	24	38.7	.043*	12	34.3	12	44.4	.034*
Walking	13	72.2	31	50.0	.161	19	54.3	12	44.4	.608
Water aerobics	3	16.7	9	14.5	.996	5	14.3	4	14.8	.722
Yoga	6	33.3	4	6.5	.007*	2	5.7	2	7.4	1.000
Swimming	-	-	1	1.6	1.000	-	-	1	3.7	.435

Note. Comparison of sedentariness and walking between G1 and G2, and between G2SF and G2RF with Chi-square test (*p < .05). Comparison of the percentage of subjects practicing water aerobics, yoga, and swimming between G1 and G2, and between G2SF and G2RF with Fisher's Exact Test (* p < .05).

Table 3

Ankle flexibility and balance test score of elderly women

Groups	Variables							
	Ankle flexibility (degrees)				Balance test (score)			
	n	Mean	SD	p	n	Mean	SD	p
G1	11	24.97	±21.3	.186	11	26.27	±2.6	.152
G2	54	32.26	±15.7		51	24.88	±2.9	
G2SF	33	37.17	±10.7	.031*	31	25.87	±2.7	.004*
G2RF	21	28.65	±17.7		20	23.70	±2.3	

Note. Comparison of ankle flexibility and performance in the balance test between G1 and G2, and between G2SF and G2RF with Student's t Test (*p < .05).

Table 4

Difficulties of G2SF and G2RF in motor tasks (MT1 to MT15) in the balance test

	Motor tasks	G2SF		G2RF		
		n	%	n	%	p
MT1	Stand still with feet together	2	6.5	2	10.0	1.000
MT2	Stand still with one foot in front of the other	14	45.2	10	50.0	.877
MT3	Stand on one foot only	13	41.9	10	50.0	.781
MT4	Forward bend	2	6.5	1	5.0	1.000
MT5	Lateral bend	4	12.9	7	35.0	.080
MT6	Forward displacement of center of gravity	17	54.8	19	95.0	.001*
MT7	Gait in place	8	25.8	7	35.0	.697
MT8	Gait forward	4	12.9	3	15.0	.999
MT9	Gait sideways	7	22.6	6	30.0	.791
MT10	Gait backwards	8	25.8	5	25.0	1.000
MT11	Gait with increased speed	6	19.4	6	30.0	.502
MT12	Stop and restart of gait	14	45.2	16	80.0	.037*
MT13	360 degree turning	3	9.7	4	20.0	.411
MT14	Walking on heels	15	48.4	16	80.0	.039*
MT15	Walking on tiptoes	10	32.3	15	75.0	.004*

Note. Comparative analysis of subgroups G2SF and G2RF. Chi-square test (MT2, MT3, MT7, MT9).

Fisher's Exact test (MT1, MT4, MT5, MT6, TM 8, MT10, MT11, MT12, MT13, MT14, MT15) (* p <. 05).

APÊNDICE 2 – ARTIGO B

Atenção à saúde de idosos diabéticos: Perfil clínico e comportamental em dois modelos de cuidados crônicos

Health care for the diabetic elderly: Clinical and behavioral profile in two chronic care models

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CSP_1629/12

Arquivos	Versão 1 [Resumo]
Seção	Artigo
Título	Atenção à saúde de idosos diabéticos: perfil clínico e comportamental em dois modelos de cuidados crônicos
Título corrido	Atenção à saúde de idosos diabéticos
Área de Concentração	Planejamento de Saúde
Palavras-chave	Diabetes Mellitus, Idosos, Atenção à Saúde, Modelos de Cuidados Crônicos
Autores	Etiene Oliveira da Silva Fittipaldi (Universidade Federal de Pernambuco) Arméle Dornelas de Andrade (Universidade Federal de Pernambuco) Paulette Cavalcanti de Albuquerque (Universidade Federal de Pernambuco) Glória Elizabeth Carneiro Laurentino (Universidade Federal de Pernambuco) Emídio Cavalcanti de Albuquerque (Instituto de Medicina Integral Prof. Fernando Figueira) Maria Teresa Jansem de Almeida Catanho (Universidade Federal de Pernambuco)

DECISÕES EDITORIAIS: [Exibir histórico]

Versão	Recomendação	Decisão	Pareceres	Data de Submissão
1	*Em avaliação.* Artigo enviado em 11 de Novembro de 2012.			

CSP_1629/12

Atenção à saúde de idosos diabéticos: perfil clínico e comportamental em dois modelos de cuidados crônicos

Arquivos (Versão 1)

Arquivo	Título	Tipo	Tamanho
csp_1629_12_1.doc	Artigo principal	Artigo	125 KB
tabela1_csp_1629_12_1.doc	Quadro 1 - Síntese da organização dos serviços de atenção aos idosos	Tabela	67 KB
tabela2_csp_1629_12_1.doc	Tabela 1 - Características dos idosos diabéticos (amostra total, G1 e G2) quanto ao gênero, estado nutricional, autonomia funcional, condição de saúde autorreferida, sintomas depressivos e nível de atividade física	Tabela	85 KB
tabela3_csp_1629_12_1.doc	Tabela 2 - Comparação entre os grupos G1 e G2 das variáveis: idade, IMC, AIVD, EDG-15 e glicemia capilar aleatória dos idosos diabéticos	Tabela	64 KB

Atenção à saúde de idosos diabéticos: perfil clínico e comportamental em dois modelos de cuidados crônicos

Health care for the diabetic elderly: clinical and behavioral profile in two chronic care models

RESUMO

Esse estudo analisou as características clínicas e comportamentais de idosos diabéticos atendidos em dois modelos de cuidados crônicos. Foram realizadas avaliações de estado nutricional, autonomia funcional, nível de atividade física, saúde autopercebida, sintomas depressivos e glicemia capilar aleatória. Dos 122 sujeitos selecionados, 77 eram assistidos em núcleos de atenção aos idosos (G1) e 45 eram de uma unidade de saúde da família (G2). Os dados foram analisados de forma qualitativa e quantitativa. Os sujeitos do G1 demonstraram muito prazer diante do convívio social e interesse pelas atividades desenvolvidas nos núcleos, quando comparados com os do G2, sendo estes mais sedentários, depressivos e com maior descontrole da glicemia. Idosos diabéticos assistidos na unidade de saúde da família apresentaram piores condições clínicas e comportamentais. Esse tipo de modelo necessita ampliar o leque de serviços multiprofissionais e criar estratégias de cuidados inovadores, persuadindo essa população a pensar e agir de formas diferentes sobre suas condições crônicas.

Palavras-chave: Diabetes Mellitus, Idosos, Atenção à Saúde, Modelos de Cuidados Crônicos

ABSTRACT

This study analyzed the clinical and behavioral characteristics of diabetic elderly patients seen in two chronic care models. The subjects were evaluated in their nutritional status, functional autonomy, physical activity level, self-perceived health, depressive symptoms, and random capillary blood glucose. From the 122 selected subjects, 77 were assisted in elderly care centers (G1) and 45 were from a family health unit (G2). The data were qualitatively and quantitatively analyzed. The G1 subjects showed delight in their social life and interest in the activities performed in the centers, both educationally and welfare related, when compared to G2 patients, who were more sedentary, depressive, and had more uncontrolled blood glucose. The diabetic seniors assisted in the family health unit had worse clinical and behavioral conditions. These results demonstrate that this kind of model needs to expand its range of multidisciplinary services and create innovative care strategies, leading this population to think and act differently regarding their chronic condition.

Keywords: Diabetes Mellitus, Elderly, Health Care, Chronic Care Models

INTRODUÇÃO

O crescimento da população idosa é um fenômeno mundial e, no Brasil, ocorre de forma bastante acelerada. A cada ano, 650 mil novos idosos são incorporados à população brasileira, a maior parte com doenças crônicas e alguns com limitações funcionais. Doenças próprias do envelhecimento ganharam maior expressão no conjunto da sociedade. No cenário atual, surge um quadro de enfermidades complexas e onerosas, típico dos países longevos, onde as doenças crônicas e múltiplas afligem as pessoas por anos, exigindo cuidados constantes, medicação contínua, exames periódicos, o que determina a maior procura dos idosos por serviços de saúde[1].

Dentre as enfermidades crônicas não transmissíveis, destaca-se o Diabetes Mellitus como uma das que acarretam muitas alterações clínicas e comportamentais. Entre as diferentes classificações do diabetes, o Diabetes Mellitus tipo 2 (DM2) é o de maior prevalência[2]. A idade do aparecimento do DM2 é variável, sendo a maior incidência em torno dos 60 anos[3] e, com relação ao gênero, é mais frequente nas mulheres que nos homens[4]. Associando esses dados ao aumento da prevalência dessa enfermidade na população, a Organização Pan-Americana da Saúde (OPAS) estima que a maioria dos diabéticos, nos próximos anos, será constituída de mulheres idosas[5].

O diabetes compõe o grupo de doenças metabólicas, que se caracteriza por hiperglicemia, resultante de defeitos na secreção e/ou ação da insulina[2,3]. As consequências, em longo prazo, dessa doença podem levar a complicações, tais como: obesidade, doenças cardiovasculares, depressão, entre outras[6].

Diante da presença de algumas complicações ou disfunções provenientes do diabetes, o pior autorrelato do estado de saúde desses idosos surge como preditor de elevado risco de mortalidade[7]. Uma das ferramentas, particularmente importante, utilizada para melhorar as condições clínicas e comportamentais dos idosos com DM2, é a atividade física, a qual, quando realizada de forma regular melhora a saúde física e psicológica, a capacidade funcional, a qualidade de vida e a independência dessa população[8].

O acompanhamento das condições de saúde dos diabéticos em todo o mundo cabe à Atenção Primária, devendo ocorrer encaminhamento aos especialistas e serviços de atenção secundária em casos de complicações ou dificuldade de compensação. No Brasil, a Atenção Primária à Saúde (APS) é realizada pelo modelo de Saúde da Família por meio das unidades de saúde da família (USF) ou pelo modelo tradicional por meio das unidades básicas de saúde (UBS), que compõem uma rede de atenção básica à saúde, considerada no Brasil por Gil, sinônimo de APS[9]. As UBS ou USF são responsáveis por acompanhar todos os idosos de suas áreas de abrangência, sejam estes portadores ou não de patologias crônicas, avaliando suas condições de saúde e orientando medidas preventivas e de promoção da saúde, como as atividades físicas. Segundo o Plano de Reorganização da Atenção à Hipertensão arterial e ao Diabetes Mellitus, cabe às equipes de saúde da família acompanhar todos os hipertensos e diabéticos, adultos e idosos por meio de consultas, atividades educativas em grupo e distribuição gratuita de medicamentos, além de ações de promoção da saúde, nas quais se inclui o estímulo à atividade física[10].

No entanto, outros serviços de acompanhamento de idosos têm se organizado, junto às universidades públicas, com características semelhantes à atenção primária. Estes disponibilizam um amplo leque de serviços aos idosos, que incluem desde atendimentos em especialidades médicas ou de saúde até cursos e atividades paralelas. Com a possibilidade de se constituírem em campos de prática para os cursos de graduação, tendem a ter disponível uma assistência multiprofissional estruturada e, de modo geral, especializada no cuidado aos idosos[11].

Os serviços de atenção aos idosos devem se integrar em Redes de Atenção à Saúde (RAS), de acordo com Mendes[12] caracterizadas como "*conjuntos de serviços de saúde, vinculados entre si por uma missão única, por objetivos comuns e por uma ação cooperativa e interdependente, que permitem ofertar uma atenção contínua e integral a determinada população, coordenada pela atenção primária à saúde*".

Ambos os serviços, universitários ou das USF, deveriam compor a RAS dos idosos, articulando-se com serviços especializados ambulatoriais, hospitalares e de apoio diagnóstico e terapêutico. As RAS têm se constituído na alternativa de cuidado aos portadores de doenças crônicas, garantindo uma atenção integral com maior resolutividade. Nas propostas dos Modelos de Cuidados Crônicos (MCC), os autores têm valorizado cada vez mais a atenção em equipes multiprofissionais, com ênfase na interação com o paciente e no investimento na garantia de autonomia dos usuários sobre sua condição de saúde. Serviços de atenção à saúde que invistam em MCC teriam assim melhor desempenho no controle das doenças e de suas complicações[13-15].

Diante do exposto, este trabalho tem por objetivo analisar e comparar o perfil dos idosos diabéticos atendidos em diferentes serviços de atenção à saúde da cidade do Recife, segundo características clínicas e comportamentais.

MÉTODOS

Estudo com delineamento transversal, de abordagem qualitativa e quantitativa, realizado no período de março a julho de 2011, envolvendo o acompanhamento de 122 idosos diabéticos voluntários selecionados por conveniência, de serviços de atenção à saúde do Recife, Pernambuco, região Nordeste do Brasil.

A amostra apresentando idade média de 70,6 (±7,1) anos, de ambos os gêneros e diagnóstico de DM2 foi dividida em 2 grupos, um grupo assistido em serviços de atenção a idosos vinculados às universidades públicas (G1, N=77) e outro na atenção primária no modelo de Saúde da Família (G2, N=45).

Os serviços de atenção a idosos das Universidades Federal e Estadual de Pernambuco se constituíram como núcleos, denominados Núcleo de Atenção ao Idoso (NAI) e Núcleo de Articulação e Atenção Integral à Saúde e Cidadania da pessoa Idosa (NAISCI), vinculados a Programas de Atenção ao Envelhecimento. São espaços voltados à valorização dos idosos, com atendimentos ambulatoriais em diversas especialidades médicas e de saúde, ligados aos hospitais universitários. Os Núcleos também promovem atividades físicas regulares assim como atividades semanais de lazer, trabalhos manuais e corporais, noções de saúde e exercício da cidadania, tendo como premissa o trabalho em equipe multidisciplinar.

O grupo de idosos da atenção primária no modelo Saúde da Família era vinculado a uma unidade da Secretaria de Saúde do Recife, constituída por três equipes. O estudo incluiu os idosos de apenas uma das equipes, que é referência para o Programa de Residência Multiprofissional em Saúde da Família da Universidade de Pernambuco, sendo responsável pelo acompanhamento de 1.492

famílias, num total aproximado de 5.200 usuários. Na época da coleta de dados, estava em implantação o Núcleo de Apoio à Saúde da Família (NASF), que ainda não havia iniciado o acompanhamento dos idosos.

O funcionamento dos serviços foi vivenciado e observado pelos pesquisadores e registrado em diário de campo, durante o período da coleta. Os dados eram discutidos pela equipe ao final de cada turno de atividade e foram posteriormente analisados qualitativamente.

Na seleção da amostra para a coleta dos dados quantitativos, foram avaliados, inicialmente, 3.271 prontuários de idosos acompanhados no NAI, no NAISCI e na USF, dos quais 871 apresentavam diagnóstico de DM2. Por meio de contatos telefônicos e/ou visitas realizadas pelos agentes comunitários de saúde, esses idosos diabéticos foram convidados a participar da pesquisa, comparecendo aos locais 198 deles. De acordo com as avaliações médicas descritas nos prontuários, foram excluídos os sujeitos que apresentaram déficit cognitivo, dependência nas atividades instrumentais, sequelas neurológicas, acuidade visual e/ou auditiva gravemente diminuídas, amputações, uso de próteses e/ou limitações físicas impeditivas de locomoção. Após a aplicação dos critérios de elegibilidade e exclusão, a amostra final foi constituída de 122 indivíduos.

Para a caracterização dos idosos, o instrumento de pesquisa compreendeu um questionário semi-estruturado que incluiu as seguintes variáveis: demográficas (gênero e idade), clínicas (estado nutricional, glicemia capilar aleatória da polpa digital, autonomia funcional e sintomas depressivos) e comportamentais (percepção da própria saúde e nível de atividade física).

Foram realizados os seguintes procedimentos:

- Classificação do estado nutricional do idoso a partir do IMC, calculado pela razão peso/altura² (Kg/m²). Foram utilizados os pontos de corte recomendados para a população idosa: desnutrição (< 22 Kg/m²), eutrofia (22 a 27 Kg/m²) e excesso de peso (> 27 Kg/m²)[16].
- Aferição da glicemia capilar aleatória, por meio de um glicosímetro (ACCU-CHEK Active - Roche), com sensores eletroquímicos para glicose, considerando o controle da glicemia capilar aleatória ≤ 200 mg/dL [2].
- Avaliação da autonomia funcional nas atividades instrumentais da vida diária (AIVD) por meio da escala de Lawton e Brody[17] com pontuação máxima de 27 pontos, sendo considerado independente (27-24 pontos), dependente parcialmente (23-17 pontos) e dependente (<17 pontos).
- Rastreamento dos sintomas depressivos por meio da Escala de Depressão Geriátrica em versão reduzida de Yesavage (EDG-15), validada no Brasil por Paradela *et al.*[18], em que o resultado de 1 a 4 pontos caracteriza ausência e ≥ 5 pontos, presença de sintomas depressivos.
- Percepção da própria saúde referida como muito boa/ boa, regular, ruim/muito ruim.
- Avaliação do nível de atividade física por meio do Questionário Internacional de Atividade Física (IPAQ), validado para população brasileira – versão curta 8.0 por Matsudo *et al.*[19], classificando os idosos em 4 categorias: muito ativo, ativo, irregularmente ativo e sedentário.

A análise dos dados foi processada, utilizando o aplicativo *Statistical Package for the Social Sciences* (SPSS) versão 15.0. Todos os testes foram aplicados com 95% de confiança. Os resultados estão apresentados em forma de tabela, com suas respectivas frequências absoluta (n) e relativa (%). As variáveis numéricas estão representadas pelas medidas de tendência central e medidas de dispersão. Foram utilizados o Teste de Normalidade de Kolmogorov-Smirnov e os Testes Qui-Quadrado de Pearson, Mann-Whitney e t Student.

O estudo foi aprovado pelo Comitê de Ética em Pesquisa com Seres Humanos do Hospital Universitário Oswaldo Cruz da Universidade de Pernambuco (125/2009 – CAAE: 0127.0.106.000-09), e os participantes assinaram o termo de consentimento livre e esclarecido.

RESULTADOS

A parte qualitativa da pesquisa demonstrou que os serviços estudados possuem processos de trabalho diferentes na atenção aos idosos diabéticos (Quadro 1).

A primeira diferença observada refere-se ao fato da USF atender a uma população territorialmente definida, fortalecendo assim o vínculo entre usuário e equipe. Nos serviços dos hospitais universitários, referência para todo o município do Recife, são atendidos idosos de todos os bairros, embora tenha se percebido maior frequência daqueles que moram perto dos hospitais. Foi notória na USF a relação direta com o profissional médico, enquanto nos outros se observou o vínculo com diversos profissionais e a participação em um conjunto mais amplo de atividades intersetoriais.

Os idosos do G1 demonstraram muito prazer diante do convívio social e interesse por todas as atividades, tanto educativas como assistenciais, enquanto os do G2 pareciam pouco interessados nas atividades educativas e de promoção à saúde oferecidas na sala de espera, sendo explícita a intenção de conseguir acesso aos medicamentos. Os hospitais não distribuem medicamentos e, portanto, os usuários precisam de vinculação a outros serviços para garantir esse acesso.

Outra diferença observada refere-se à composição da equipe responsável pela atenção aos idosos diabéticos. A USF conta com médico, enfermeiro, auxiliar de enfermagem e agente comunitário de saúde para esse acompanhamento. Neste serviço, havia, até outubro de 2010, residentes de saúde da família nas áreas de fisioterapia, terapia ocupacional, educação física, odontologia, farmácia, fonoaudiologia, psicologia e serviço social. Os residentes atuavam em três USF, com oito equipes de saúde da família, numa população de aproximadamente 30 mil habitantes. Diante do grande número de usuários, atendiam pontualmente pacientes selecionados pelas equipes, considerados de mais alto risco, discutindo casos e desenvolvendo atividades educativas com o Grupo de Idosos “Sabedoria de Vida”. Na segunda metade do ano de 2010, concomitantemente com a saída dos residentes, foi implantado o NASF na região contando com psicólogo, assistente social, farmacêutico, nutricionista e fisioterapeuta. Estes iniciaram suas atividades em agosto de 2010, atendendo a 8 USF, correspondentes a 16 equipes e uma população com cerca de 60 mil habitantes, o que acarretou uma redução do acesso dos idosos a esses profissionais, que desenvolviam atividades geralmente uma vez por mês na USF. O NAI e o NAISCI contam diretamente com uma equipe multiprofissional e também com a parceria dos demais profissionais das universidades federal e estadual, respectivamente, que desenvolvem projetos específicos na área de envelhecimento.

Considerando os resultados encontrados na avaliação quantitativa dessa pesquisa, a Tabela 1 demonstra que a maioria dos idosos pertencia ao gênero feminino (76,2%), independente nas AIVD (74,4%), apresentou excesso de peso

(78,7%) e referiu sua condição de saúde de regular a muito ruim (89,3%). Quanto ao nível de atividade física, 57,8% da amostra total eram sedentários, mas quando comparados os grupos G1 e G2, os idosos do G2 apresentaram, significativamente, um maior comportamento sedentário (p=0,043). Na análise da presença dos sintomas depressivos, a amostra total apresentou 31,4%, e, na comparação dos grupos, o G2 apresentou maior sintomatologia depressiva (p=0,007). Não houve idosos ativos ou muito ativos, de acordo com o IPAQ.

A Tabela 2 mostra que ambos os grupos apresentaram uma média no IMC compatível com excesso de peso, assim como independência nas AIVD, sem diferença entre eles. Entretanto, a média da idade do G1 foi maior (p=0,025), os sintomas depressivos estavam mais presentes no G2 (p=0,003), e a média da glicemia capilar aleatória do G2 foi significativamente mais elevada (p=0,006).

DISCUSSÃO

Os idosos diabéticos do G1, embora significativamente mais velhos, apresentaram condições clínicas e comportamentais melhores, quando comparados com o G2. Araújo *et al.*[20] em uma revisão da literatura evidenciaram que os serviços de atendimento aos idosos, vinculados às instituições de ensino têm sido apresentados como boas alternativas para o atendimento integral à saúde do idoso no Brasil.

O predomínio do gênero feminino, da independência nas AIVD, do excesso de peso e da autopercepção da saúde regular a muito ruim foi encontrado em toda amostra estudada, porém os sintomas depressivos, o comportamento sedentário e a hiperglicemia aleatória foram significativamente maiores no G2, sugerindo que nesse grupo, haja uma maior vulnerabilidade às complicações advindas do diabetes ou um acompanhamento mais precário.

A predominância do gênero feminino na amostra estudada pode refletir não só o maior percentual de mulheres com DM2 nessa faixa etária como também a maior procura dos serviços de saúde por parte delas, aumentando, assim, a possibilidade de prevenção, diagnóstico e tratamento[4,5,21].

Embora a maioria dos idosos apresentasse independência nas AIVD, 25,6% apresentaram dependência parcial. Sabe-se que o DM, por ser uma doença crônica, pode levar a incapacidades funcionais, portanto a melhora ou, no mínimo, a manutenção da capacidade funcional tem sido um dos objetivos mais importantes e desafiantes no acompanhamento da evolução clínica desses idosos[22,23].

O resultado da média do IMC caracterizou sobrepeso tanto para a amostra total quanto para os grupos G1 e G2, corroborando o estudo de Gomes *et al.*[24] que, ao avaliarem pacientes com DM2 em um estudo multicêntrico, nas diferentes regiões do Brasil, indicaram que o sobrepeso e a obesidade atingiram um percentual próximo a essa pesquisa (75,0%) e que o gênero feminino foi o mais acometido.

As avaliações das condições de saúde autorreferida também têm sido utilizadas como preditoras de elevados riscos de mortalidade em idosos quando associada ao pior relato do estado de saúde, e os diabéticos têm apresentado maior prevalência de percepção da própria saúde como ruim ou muito ruim, comparados aos não diabéticos[7], sendo consequência da interação de diversos fatores, tais como o aumento da idade, a presença de comorbidades e de incapacidades funcionais[25].

Analisando os resultados desse estudo comparativamente, os indivíduos assistidos na USF apresentaram, de forma significativa, valores mais elevados de glicemia capilar aleatória, mais sintomas depressivos, além de serem mais sedentários.

Sabe-se que a hiperglicemia é o principal determinante do dano tecidual causado pelo DM, resultando em aumento de glicose intracelular, promovendo, assim, o início da patogênese das complicações do diabetes, incluindo perda da função normal e falência de vários órgãos[2,3]. Quando a intervenção é precoce, esses danos podem ser reversíveis, se restaurada a condição de normoglicemia. Sendo assim, o controle glicêmico deve ser o principal alvo a ser atingido no tratamento do diabetes, mas as pesquisas apontam que a hiperglicemia também está associada à presença de obesidade, de sintomas depressivos e de inatividade física. Esses aspectos fazem crer que a atenção ao idoso diabético deve ter um enfoque mais amplo[6,26].

Embora todos os idosos diabéticos devam ser acompanhados pela APS, Facchini *et al.*[27] verificaram que apenas 35,9% destes, na região Nordeste, realizaram consulta médica nos últimos seis meses, na UBS tradicional, sendo que os idosos residentes em áreas de abrangência de UBS com modelo PSF realizaram 48% de consultas médicas. O acesso gratuito a medicamentos para o controle do diabetes é bem maior na atenção básica no modelo PSF, chegando a 66,2% nas USF da região Nordeste. Mas, é preciso uma maior integração entre programas e clara definição de responsabilidades para otimizar a aquisição de medicamentos, aumentando a efetividade da assistência farmacêutica[28].

Neste estudo, foi encontrado um percentual elevado de sintomas depressivos nos idosos diabéticos, principalmente no G2, podendo ele ser decorrente do fato de a amostra ser composta, na maioria, por mulheres sedentárias.

A depressão tem sido uma condição clínica frequente em idosos vivendo na comunidade, apresentando alta prevalência em indivíduos portadores de diabetes, principalmente do gênero feminino[29]. Em relação aos sintomas depressivos, estes se relacionam a um pior controle glicêmico, a um aumento e a uma maior gravidade das complicações clínicas, a uma piora da qualidade de vida e ao comprometimento de aspectos sociais, econômicos e educacionais ligados ao DM[30]. O tratamento da depressão está relacionado à melhora dos níveis glicêmicos, podendo contribuir para um melhor controle de diversos aspectos relacionados ao DM[31].

Um estudo realizado por Calhoun *et al.*[32], além de afirmar que a depressão está mais presente nos diabéticos e no sexo feminino, associou a gravidade da depressão com as alterações do IMC e do controle glicêmico. Held *et al.*[33] ao avaliarem a atenção primária dada aos diabéticos em Samoa Americana, constataram que os sintomas depressivos estavam diretamente ligados à presença de hiperglicemia e à maior ingestão de alimentos, principalmente quando surgiam sentimentos de depressão ou situações difíceis.

Entretanto, pesquisas relataram que, nos diabéticos, os altos níveis de sintomas depressivos estão associados ao menor apoio social e à diminuição do desempenho do autocuidado, pois a depressão impede a adoção de comportamentos eficazes de autogestão (incluindo atividade física, comportamento alimentar adequado e medidas de automonitoramento no controle da glicemia), por meio de uma diminuição da motivação social, aumentando, assim, as complicações advindas do DM2[34,35].

Quando comparado o desempenho de atividade física entre os dois grupos desse estudo, constatou-se maior prevalência de sedentarismo entre os idosos do G2.

A atividade física é um importante componente no tratamento do diabetes e na promoção do envelhecimento saudável, uma vez que melhora a sensibilidade insulínica, o controle glicêmico e reduz os fatores de riscos cardiovasculares, como a hipertensão e a dislipidemia, além de retardar o declínio da capacidade funcional e a perda da autonomia decorrente do avanço da idade. Também fornece muitos benefícios psicológicos relacionados à preservação da função cognitiva e ao alívio dos sintomas de depressão[8].

No cenário da APS no Brasil, Piccini *et al.*[36] relataram que um terço dos idosos de sua amostra avaliou sua saúde positivamente, dois terços apresentaram conhecimentos considerados desejáveis para manter boa saúde, mas a prática da atividade física foi pouco frequente. Facchini *et al.*[27] descreveram que, durante as consultas nas USF das regiões Sul e Nordeste, a recomendação médica de atividade física para os idosos variou de 27,2% a 45,2%. Siqueira *et al.*[37] referiram que 73,8% dos idosos de sua amostra identificaram a atividade física como benefício para a saúde. Mas Alves *et al.*[38], ao avaliarem o nível de atividade física de adultos e idosos moradores em áreas de unidades básicas de saúde em Pernambuco, encontraram a prevalência de sedentarismo entre os adultos de 37,1% e entre os idosos, 68,3%, e também a não prescrição de atividade física no último ano para os idosos de 69,7%.

Tornou-se um grande desafio para os profissionais da atenção primária manter a saúde física e mental, a independência e a mobilidade dos idosos com DM2. Estudos brasileiros recentes demonstraram que o tratamento destinado a essa população, predominantemente idosa, sedentária, do sexo feminino, de baixa escolaridade, de baixa renda e com disfunções alimentares, era basicamente medicamentoso e que há de se destacar a importância de uma equipe de saúde multiprofissional, melhor capacitada, visando a uma melhor qualidade da assistência prestada[25,36,38,39]. Segundo Mendes[40], "*a composição vigente da planta de pessoal, fortemente ancorada nos médicos e enfermeiros, é insuficiente para dar conta do manejo das condições crônicas pelo PSF que convoca outros profissionais como membros orgânicos, e não somente como apoiadores das equipes, como propõe a política dos NASF".*

Além da ampliação da equipe profissional, de acordo com Piccini *et al.*[36] também seria necessária uma melhor capacitação desta. Em estudo na região Nordeste, menos de 50% dos profissionais de saúde eram capacitados para o cuidado do diabetes no PSF. Facchini *et al.*[27], ao realizarem uma avaliação institucional e epidemiológica da Atenção Básica à Saúde no Brasil, evidenciaram que, para maior benefício da população e melhor desempenho do PSF diante das metas da Conferência de Alma-Ata, há necessidade de estímulo financeiro, técnico e político à rede básica de saúde no país.

Segundo Sartorelli *et al.*[41], os dados provenientes de países em desenvolvimento são escassos, mas os estudos disponíveis referem melhoria da qualidade de vida de indivíduos com elevado risco metabólico por meio de medidas simples de intervenção adaptadas às condições usuais de UBS. Entretanto, a implementação de programas de mudança de estilo de vida em indivíduos portadores de fatores de risco deve ser associada a alterações ambientais que favoreçam as escolhas individuais na adoção e manutenção do estilo de vida saudável. Mesmo em países desenvolvidos, o estudo de Auchincloss *et al.*[42] sugere que a melhora das características ambientais com melhores recursos próximos à residência do idoso está associada à menor incidência de DM2 e pode ser uma estratégia populacional viável para enfrentar essa doença e suas complicações.

Os resultados dessa pesquisa indicam a necessidade de melhorar a qualidade dos cuidados prestados aos idosos portadores de DM2, especialmente com a inclusão de equipes multiprofissionais e da ampliação do leque de atividades disponíveis aos usuários. Um maior esforço deve ser despendido pelas equipes de saúde para promover a adesão desses pacientes à dieta, ao exercício, à medicação, às práticas de educação em saúde, valorizando também as orientações relativas às mudanças de estilo de vida, já que essa população é mais vulnerável a apresentar associação de doenças crônicas e maior risco de morbimortalidade.

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Quadro 1 – Síntese da organização dos serviços de atenção aos idosos.

Serviço	G1		G2
	NAI-UFPE	NAISCI-UPE	USF/ESF
População de referência	1,5 milhão de habitantes / 712 diabéticos.		5.200 habitantes / 159 diabéticos.
Mecanismos de acesso	Procura direta e encaminhamentos.		Procura direta e ACS.
Profissionais envolvidos diretamente no atendimento ao idoso diabético	Médico geriatra, endocrinologista, nutricionista, terapeuta ocupacional, psicólogo, odontólogo.	Médico geriatra, endocrinololgista, assistente social, enfermeiro e terapeuta ocupacional.	Médico, enfermeiro, auxiliar de enfermagem e ACS.
Acesso às atividades com a equipe multiprofissional	Semanal. De acordo com a programação das atividades propostas.		Indefinida. Semanal para usuários do Grupo de Idosos "Sabedoria de Vida".
Acesso ao atendimento individual com a equipe multiprofissional	Semanal, quando necessário. De acordo com o encaminhamento da equipe.		Raramente. Em casos de maior necessidade, a ESF solicitava aos residentes ou ao distrito sanitário.
Periodicidade do acompanhamento médico	Semestral, para idosos sem intercorrências clínicas, dependendo da demanda das marcações. Mensal, quando necessário.		Mensal, em atendimento coletivo no Hiperdia ou em consulta individual, quando necessário.
Acesso a atividades intersetoriais	Frequentemente (escola do estatuto do idoso, oficina de envelhecimento saudável, educação continuada, yoga, natação, caminhadas, hidroginástica, dentre outras)		Raramente

Tabela 1 – Características dos idosos diabéticos (amostra total, G1 e G2) quanto ao gênero, estado nutricional, autonomia funcional, condição de saúde autorreferida, sintomas depressivos e nível de atividade física.

Variáveis	Amostra total		G1		G2		
	n	%	n	%	n	%	p
Gênero							0,723*
Masculino	29	23,8	17	22,1	12	26,7	
Feminino	93	76,2	60	77,9	33	73,3	
†Estado nutricional (IMC)							0,511*
Desnutrição	1	0,9	-	-	1	2,4	
Eutrofia	24	20,5	14	18,4	10	24,4	
Excesso de peso	92	78,7	62	81,6	30	73,2	
†Desempenho nas AIVD							0,595*
Independente	90	74,4	59	76,6	31	70,5	
Dependente parcial	31	25,6	18	23,4	13	29,5	
Condição de saúde autorreferida							0,099*
Muito boa / Boa	13	10,7	6	7,8	7	15,5	
Regular	71	58,2	51	66,2	20	44,4	
Ruim / Muito ruim	38	31,1	20	26,0	18	40,0	
†Sintomas depressivos (EDG-15)							0,007*
Presença	38	31,4	17	22,1	21	47,7	
Ausência	83	68,6	60	77,9	23	52,3	
†Nível de atividade física (IPAQ)							0,043*
Irregularmente ativo	35	42,2	28	50,9	7	25,0	
Sedentário	48	57,8	27	49,1	21	75,0	

* Teste Qui-Quadrado de Pearson. †Os totais dessas variáveis não somam 100% por falta de informação.

Tabela 2 - Comparação entre os grupos G1 e G2 das variáveis: idade, IMC, AIVD, EDG-15 e glicemia capilar aleatória dos idosos diabéticos.

Variáveis	Amostra total		G1		G2		
	Média	±DP	Média	±DP	Média	±DP	p
Idade (anos)	70,6	7,1	71,7	6,6	68,8	7,6	0,025**
IMC (Kg/m^2)	28,8	5,3	29,3	4,9	28,4	5,9	0,367**
AIVD (pontos)	24,8	2,8	24,7	3,1	24,9	2,2	0,915***
EDG-15 (pontos)	3,8	2,9	3,2	2,6	4,9	3,4	0,003***
GCA (mg/dL)	206,6	99,8	188,5	86,8	245,3	115,4	0,006**

Teste t Student. * Teste de Mann-Whitney.

APÊNDICE 3 – ARTIGO C

Diabetic Elderly Women: Predominance of Functional Dependence, Overweight, and Sedentariness

Idosas Diabéticas: Predomínio de Dependência Funcional, Excesso de Peso e Sedentarismo

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Elsevier Editorial System(tm) for Diabetes Research and Clinical Practice
Manuscript Draft

Manuscript Number: DIAB-D-12-01137

Title: Diabetic Elderly Women: Predominance of Functional Dependence, Overweight, and Sedentariness

Article Type: Clinical Care and Education (5000 words)

Keywords: Elderly; Type 2 Diabetes Mellitus; Activities of Daily Living; Overweight; Sedentary Lifestyle

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Abstract: Aims: To compare the functional capacity, nutritional status and physical activity level of diabetic elderly women and non-diabetic. Methods: A cross-sectional study carried out in an elderly care service from July to September 2011. The sample consisted of 88 elderly women with a mean age of 69.1 ±4.6 years, being a group of 44 women with type 2 diabetes mellitus and the control group with 44 non-diabetic women. We evaluated independence in the Instrumental Activities of Daily Living (IADL) using the Lawton and Brody Scale, nutritional status with anthropometric measurements (BMI), and physical activity level with the International Physical Activity Questionnaire (IPAQ), version 8.0. Data analysis was performed using Pearson Chi-Square and Mann-Whitney Tests. Results: Compared to the control group, the diabetic group obtained a lower total score in the IADL (24.7 ± 2.6) (p=0.011) and more partial dependence in the activities (25.0%) (p=0.041). They presented a higher frequency of overweight (79.5%) (p=0.004), as well as a higher mean BMI (30.7 ±4.7 kg/m2) (p=0.001). Regarding the IPAQ, the diabetic group was more sedentary (63.6%) (p=0.001). Conclusions: Overweight and obesity are still part of the nutritional status of most diabetic elderly women, who become more functionally dependent and more sedentary. All these factors are modifiable, so it is necessary to implement health actions that will minimize the negative impact on the quality of life of this population.

Diabetic Elderly Women: Predominance of Functional Dependence, Overweight, and Sedentariness

Short Title: Diabetic Elderly Women

ABSTRACT

Aims: To compare the functional capacity, nutritional status and physical activity level of diabetic elderly women and non-diabetic. **Methods:** A cross-sectional study carried out in an elderly care service from July to September 2011. The sample consisted of 88 elderly women with a mean age of 69.1 ±4.6 years, being a group of 44 women with type 2 diabetes mellitus and the control group with 44 non-diabetic women. We evaluated independence in the Instrumental Activities of Daily Living (IADL) using the Lawton and Brody Scale, nutritional status with anthropometric measurements (BMI), and physical activity level with the International Physical Activity Questionnaire (IPAQ), version 8.0. Data analysis was performed using Pearson Chi-Square and Mann-Whitney Tests. **Results:** Compared to the control group, the diabetic group obtained a lower total score in the IADL (24.7 ± 2.6) (p=0.011) and more partial dependence in the activities (25.0%) (p=0.041). They presented a higher frequency of overweight (79.5%) (p=0.004), as well as a higher mean BMI (30.7 ±4.7 kg/m^2) (p=0.001). Regarding the IPAQ, the diabetic group was more sedentary (63.6%) (p=0.001). **Conclusions:** Overweight and obesity are still part of the nutritional status of most diabetic elderly women, who become more functionally dependent and more sedentary. All these factors are modifiable, so it is necessary to implement health actions that will minimize the negative impact on the quality of life of this population.

Keywords: Elderly; Type 2 Diabetes Mellitus; Activities of Daily Living; Overweight; Sedentary Lifestyle

1. INTRODUCTION

The elderly population growth is a worldwide phenomenon, which tends to increase the prevalence of non-communicable chronic diseases and thus the development of physical disabilities. This setting has created a new paradigm for the health care of this population [1]. The aging process has brought a sharp increase in obesity [2] and physical inactivity [3], which are directly associated with functionality and the ability to perform routine activities.

Functional capacity refers to the individual's ability to perform their Activities of Daily Living (ADL) like bathing, dressing, transferring, having continence and feeding, as well as perform the Instrumental Activities of Daily Living (IADL) such as cooking, cleaning, telephoning, doing the laundry, shopping, taking care of household finances and taking medication [1,4], that is, the ability to perform ordinary and desirable activities in society. In turn, incapacity is the result of the interaction of the individual's disorder, the limitation of their activities and the restrictions in social participation, thus limiting their autonomy and quality of life, resulting in increased institutionalization and premature death [5].

Type 2 Diabetes Mellitus (T2DM) is among the chronic disabling diseases. It affects 246 million people worldwide, with increasing prevalence with aging. It affects 18.6% of the elderly population nowadays [6]. The disease consists of a serious chronic metabolic disorder of multiple etiology, with slow and progressive evolution, characterized by chronic hyperglycemia with disturbances in the metabolism of carbohydrates, fats and proteins. It is originated from insulin's defective secretion and/or action in target-tissues [7].

With aging there is a higher proportion of elderly patients with T2DM and thus its complications are broadened. Besides its most common acute complications (diabetic ketosis and ketoacidosis, diabetic coma and hypoglycemia) and the chronic ones (retinopathy, nephropathy, neuropathy and diabetic macroangiopathy), diabetes has been associated with a high-risk of physical and cognitive decline, injury due to falls, fractures, and depression [8].

A study suggests that sedentariness is a risk factor as important as inadequate diet in the etiology of obesity and it has a direct and positive relationship with the increased incidence of T2DM [9], correlating itself to the decline of functional capacity in the elderly [10]. Therefore, this study aimed to compare the functional capacity, nutritional status and physical activity level in diabetic elderly women and non-diabetic.

2. MATERIALS AND METHODS

A cross-sectional and comparative study, which is part of a research line developed for the doctorate degree in Biochemistry and Physiology in a public university in Recife, Brazil, in partnership with the nucleus of elderly care (NEC) from the same institution. The research was approved by the Ethics Committee on Human Research (CAAE: 0127.0.106.000-09). Informed consent was obtained from all participants after an explanation of the objectives and methods of the current study, their rights and procedures to protect personal information. Data collection was initiated after approval of the committee during the period July to September 2011.

The inclusion criteria were age above 60, type 2 diabetes diagnosis, female, and participation in multidisciplinary activities offered by NEC. According to the evaluation described in the medical records, it was excluded from the sample elderly women who had cognitive deficits, neurological sequelae, severely impaired visual and/or hearing acuity, more than five chronic diseases, amputations, prosthesis, and/or physical constraints limiting locomotion with muscle and/or joint pain.

2.1 Sample

The medical records of 3.271 elderly women were evaluated for the sample selection for the doctorate degree research. A diagnosis of DM2 was found in 21.8% of them. The subjects were invited, by telephone, to take part in the research. 27.8% of them agreed to participate and attended the first meeting. After applying the eligibility criteria of this study, the diabetic elderly sample consisted of 44 subjects, forming the diabetic group (DG). In addition, 54 non-diabetic elderly, who also participated in NEC multidisciplinary activities, were also invited, composing the control group (CG). The age-matching technique, which increases the efficiency of statistical tests, making them more sensitive to small differences between groups, was then applied and the final sample of CG comprised 44 non-diabetic elderly women. The elderly had a mean age of 69.1 (±4.6).

2.2 Procedures

The independent variables in this study were: Functional capacity, nutritional status and physical activity level. In order to characterize the study sample according to these variables, a form was filled out containing the interviewee's identification and the following methodological procedures:

2.2.1 Evaluation of functional autonomy in the Instrumental Activities of Daily Living (IADL) according to the Lawton and Brody scale [11]. It was considered the maximum score of 27 points, with the following classification: independent (27-26 points), partially dependent (25-10 points) and completely dependent (<10 points).

2.2.2 The nutritional status assessment was performed by anthropometric measurements of weight and height. The body mass index (BMI) was obtained by two primary measures: weight divided by square height (kg/m²). In order to classify the nutritional status of the subjects with the BMI, we used the cutoff points recommended for the elderly population [12]: malnutrition (<22 kg/m²), eutrophy (22 to 27 kg/m²) and overweight (> 27 kg/m²).

2.2.3 The physical activity level assessment was performed using the International Physical Activity Questionnaire (IPAQ) - short version 8.0. The IPAQ was validated in a sample of the Brazilian population [13] in its short version through an interview including questions regarding the frequency and duration of moderate and vigorous physical activity and walking. The elderly were classified in four categories: very active, active, irregularly active and sedentary.

2.3 Statistical analysis

Descriptive analysis was used to characterize the sample. The statistical analysis was performed using the software SPSS (Statistical Package for the Social Sciences), Version 15.0. All tests were applied with 95% confidence, and statistical significance level was set at $p<0.05$. The tests applied were Kolmogorov-Smirnov test for normality, Pearson Chi-Square and Mann-Whitney tests. The results are presented in tables.

3. RESULTS

The total sample showed that most of the interviewees were independent (84.1%), overweight (63.6%) and irregularly physically active (55.7%), as pointed out in Table 1.

Table 2 compares the person with diabetes group and the control groups regarding age and the total score on the Instrumental Activities of Daily Living and Nutritional Status. The Instrumental Evaluation of Daily Living demonstrated that the mean score of the diabetic group was 24.7 ± 2.6 points, whereas in the control group the mean was 26.1 ± 1.4 points. This difference was significant (p=0.011). Regarding the total BMI, the groups significantly differed (p=0.001). The diabetic group showed a mean of 30.7 ± 4.7 kg/m^2, higher than that found in the control group, which was 26.9 ± 4.6 kg/m^2.

The relative and absolute frequencies of the classification of Functional Capacity in IADL, Nutritional Status and Physical Activity Level are expressed in Table 3. Considering the cutoff point for adequate functional capacity in IADL, it was observed that the group of diabetic women presented a significantly more frequent partial dependence (25.0%) than the control group (6.8%) (p=0.041). There were no totally dependent elderly in the groups.

The nutritional status classification revealed that the diabetic group presented a higher incidence of overweight subjects (79.5%) compared to the control group (47.7%) (p=0.004). There were no underweight subjects in the groups.

Regarding the Physical Activity Level classification, the diabetic group was more sedentary (63.6%) than the control group (25.0%). This difference was significant (p=0.001). None of the subjects were identified as very active or active.

4. DISCUSSION

Most of the elderly women were functionally independent, but with a high incidence of overweight and irregular physical activity. However, the partial dependence in Instrumental Activities of Daily Living, overweight, and sedentary lifestyle were significantly over-represented in the group of elderly diabetics.

A study on elderly people, aged between 60 and 104 and mostly women, points out that the occurrence of functional incapacity in the Instrumental Activities of

Daily Living was present in less than half of the interviewees [14], corroborating the findings presented here. Conversely, diabetes has been mentioned as an important contributor to the increase of functional dependence in older adults [15,16]. Elderly people with diabetes have difficulties in walking, going up and down stairs, doing housework, thus demonstrating worse functional performance when compared to non-diabetics [17]. These findings are similar to the ones noted in this study. In Mexico, a study with elderly people indicates that the limitation in IADL is almost two times higher in diabetics compared to non-diabetics, being more significant in females and in those with advanced age [18]. Again, these findings are in accordance to the ones in this paper.

It is important to highlight that the presence of cardiovascular disease [19] and obesity associated with uncontrolled glucose, are responsible for much of the functional deficits in the elderly diabetics, being directly related to the reduction of cardiopulmonary reserve and low exercise tolerance [17]. In addition, one should take into account that other co-morbidities prevalent in this population, such as visual impairments, ulcerations and amputations [20] and cognitive decline [15], may exacerbate the impact on the their overall functionality. Such conditions were considered as exclusion criteria for this study.

With regard to nutritional status, the overweight seen in the elderly studied in this paper is consistent with findings mentioned in other studies [2, 21]. These data are of concern since there is a negative relationship between abnormal weight and functional performance, as demonstrated in a population-based study on elderly people living in Latin America and the Caribbean and there is a statistically significant correlation between obesity and a greater decline in the activities of daily living [22]. It is also suggested that there is an association between obesity and poorer quality of life in the elderly, being significant the relation between overweight and a tendency to isolation, stress, depression, and deterioration of functional capacity [23].

The literature has indicated the occurrence of overweight and obesity as a factor significantly associated with the occurrence of diabetes in the elderly [22, 24, 25]. The scientific community recommends weight reduction and control as a major strategy for the non-pharmacological treatment of DM [26] in order to lower blood glucose levels, as well as slow down the progression of the disease, thus reducing the need for insulin and other drugs [27].

In addition, there is evidence that a physically inactive lifestyle may be associated with the growing number of elderly people with T2DM [28]. Physical activity associated with healthy eating habits can modify determinant factors of obesity, confirming that weight control together with increasing physical activity significantly contribute to the normalization of blood glucose levels in elderly diabetic patients [29].

A physically active lifestyle can improve physiological data such as lowering triglycerides and LDL cholesterol, increasing HDL cholesterol, decreasing rest and active heart rate as well as lowering blood pressure [30]. This fact is even more important in patients with T2DM, since the risk of mortality by coronary heart disease is higher in these subjects compared to those who do not show this morbidity [31].

A study with elderly women in Paraná demonstrated that 87.8% of those who were overweight had a low level of functional fitness [2]. Functional fitness is directly related to the individual's ability to perform activities of daily living without difficulty [32]. Thus, sedentariness, associated with an increased number of chronic diseases, favors increased functional disability in the elderly [33]. From this perspective, the practice of physical activity is essential for the maintenance of functional capacity, improving physical fitness in relation to coordination, strength, balance and flexibility [34, 35]. Systematic review of literature points out that randomized clinical trials have shown that changes in lifestyle of elderly diabetics, with regard to reducing body fat and engaging in moderate physical activity, can reduce the progression of T2DM and thus minimize the risks of functional dependency in this population [36].

Brazil does not escape from the global trend of bad eating habits, sedentariness and consequent obesity, which are etiopathogenic factors of diabetes and predisposing factors for decreased ability to perform daily activities. Therefore, it is evident the need to implement prevention programs focused on lifestyle intervention in this population, including actions aimed at controlling body fat and encouraging regular physical exercises in order to minimize damages to functional capacity.

5. CONCLUSIONS

Diabetic elderly women have a higher level of functional dependence, overweight and sedentary lifestyle. These results indicate that overweight and obesity continue to be part of the nutritional status of most of them, accompanied by low levels of physical activity and predisposition to functional dependence. All these factors are modifiable. So, it is necessary to implement health actions that will minimize the negative impact on the quality of life of this population, creating strategies to encourage behavioral changes to reduce the incidence of diabetes and the complications of this disease in the elderly.

Conflict of interest statement

None.

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Table 1 – Characterization of the total sample as to functional capacity, nutritional status and physical activity level.

Variables	n	%
Functional capacity (by IADL)		
Independent	74	84.1
Partially dependent	14	15.9
Nutritional status (by BMI)		
Eutrophy	32	36.4
Overweight	56	63.6
Physical activity level (by IPAQ)		
Irregularly active	49	55.7
Sedentary	39	44.3

IADL (Instrumental Activities of Daily Living), BMI (Body Mass Index), IPAQ (International Physical Activity Questionnaire).

Table 2 – Comparative distribution of elderly diabetic and control groups with respect to age, IADL and BMI.

Variables	Total Sample			DG			CG			
	n	Mean	Sd	n	Mean	Sd	n	Mean	Sd	p
Age (years)	88	69.1	±4.6	44	69.1	±4.6	44	69.1	±4.6	0.980
IALD (points)	88	25.4	±2.2	44	24.7	±2.6	44	26.1	±1.4	0.011*
BMI (Kg/m^2)	88	28.8	±5.0	44	30.7	±4.7	44	26.9	±4.6	0.001*

DG (diabetic group), CG (control group), IADL (Instrumental Activities of Daily Living), BMI (Body Mass Index). Mann-Whitney Test. *p≤0.01.

Table 3 – Association of IADL, BMI, and IPAQ classifications in the elderly diabetic group (DG) and the control group (CG).

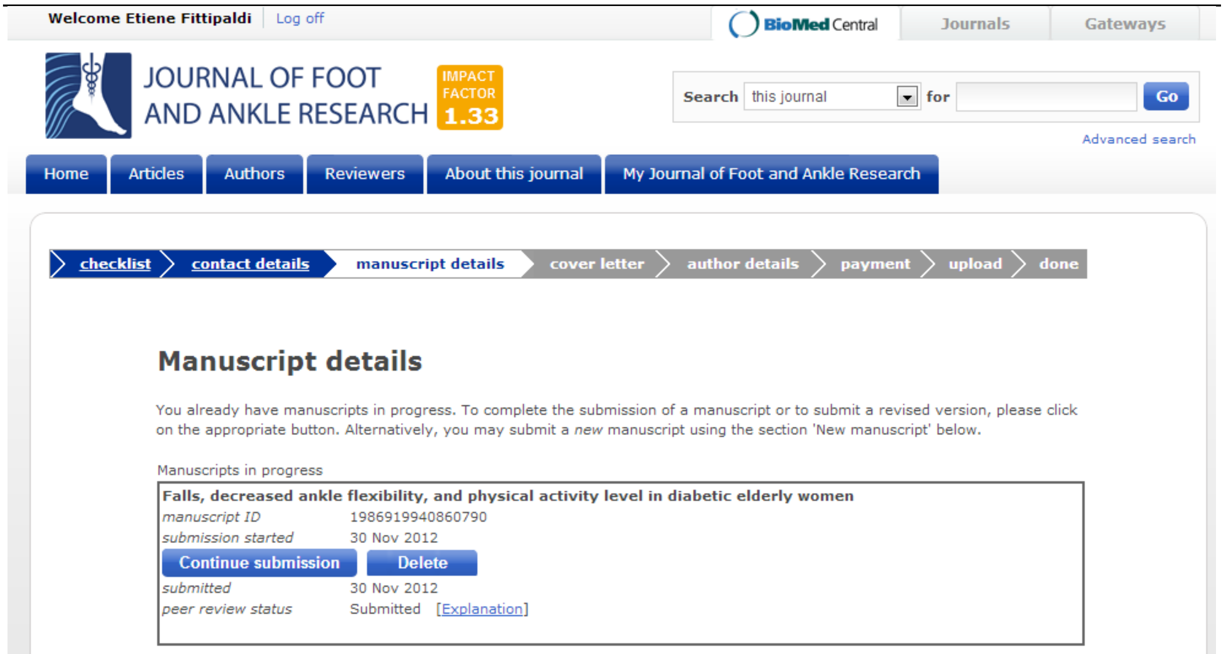
Variables	DG		CG		
	n	%	n	%	p
Functional capacity (IADL)					
Independent	33	75.0	41	93.2	0.041**
Partially dependent	11	25.0	03	6.8	
Nutritional status (BMI)					
Eutrophy	09	20.5	23	52.3	0.004*
Overweight	35	79.5	21	47.7	
Physical activity level (IPAQ)					
Irregularly active	16	36.4	33	75.0	0.001*
Sedentary	28	63.6	11	25.0	

IADL (Instrumental Activities of Daily Living), BMI (Body Mass Index), IPAQ (International Physical Activity Questionnaire). Pearson Chi-Square Test. *p≤0.01. **p<0.05.

APÊNDICE 4 – ARTIGO D

Falls, decreased ankle flexibility, and physical activity level in diabetic elderly women

Quedas, flexibilidade de tornozelo e nível de atividade física em idosas diabéticas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Falls, decreased ankle flexibility, and physical activity level in diabetic elderly women

Abstract

Background: The present study is justified by the need of conducting research involving the association of ankle flexibility with the prevalence of falls and the level of physical activity in diabetic elderly women. **Methods:** Data collection was conducted in June and July 2011. The eligibility criteria for the research were the following: community-dwelling individuals aged 60 or more, female, diagnosed with T2DM, and who presented a walking gait without assistive devices. The subjects who had all the eligibility criteria were invited to participate voluntarily in the research and those with no diagnosis of T2DM were part of the control group. The independent variables in this study were: age, falls, physical activity level, dorsal flexion, plantar flexion, and ankle flexibility. Data analysis was processed using the Software SPSS 15.0. The Pearson Chi-Square, and Student's t tests were applied with 95 percent confidence. **Results:** The sample was composed of 33 diabetic elderly women and 30 non-diabetic elderly women. The mean number of falls in the previous year had been 1.17 ±1.11, and frequency of falls, 76.19%. Only 26.98 percent of the sample was sedentary. The mean ankle flexibility was 38.32 ±10.6, while the dorsiflexion and plantar flexion mean were respectively 13.75 ±5.7 and 24.57 ±7.26 degrees. The diabetic elderly women suffered more falls in the previous year and showed a greater reduction of ankle flexibility, characterized mainly by the significant decrease in dorsiflexion amplitude. **Conclusions:** Diabetic elderly women are more prone to recurrent falls and decreased ankle flexibility, particularly dorsiflexion, which is associated with the fall event.

Keywords: Ankle, Diabetes Mellitus, Elderly, Falls, Flexibility

Introduction

Diabetes is an important health condition for the aging population; at least 20% of patients over 65-years-old have diabetes, and this number is expected to grow quickly in the coming decades. Diabetes mellitus is associated with an increased prevalence and incidence of the geriatric syndrome: functional disabilities, depression, cognitive impairment, urinary incontinence, malnutrition and falls.{1}

Older adults with type 2 diabetes mellitus (T2DM) have an increased risk of falling. Falls may lead to fractures and reduction in the quality of life of diabetic people.{2} Even non-injurious falls can result in a post-fall syndrome characterized by anxiety and reduced physical and social activities.[3] Studies show that poor balance and poor lower extremity function are important predictors of falling among diabetic women{4} and that frequent fallers have foot problems, mainly decreased ankle flexibility.{5}

Type 2 diabetes patients have poorer neuromusculoskeletal variables and the long lasting diabetes is associated with reduced muscle strength and diminished range of motion (ROM). Therapeutic exercises soon after the diagnosis may help slow down the progression and complications of diabetes.{6}

Thus, the present study is justified by the need of conducting research involving the correlation of ankle flexibility with the incidence of falls and the level of physical activity in diabetic elderly women.

Materials and Methods

The present cross-sectional comparative study was carried out with a sample of community-dwelling elderly women from the city of Recife, Brazil. The project was approved by the Research Ethics Committee of the University of Pernambuco (CAAE: 0127.0.106.000-09). The participants signed a Free and Clarified Consent Term.

All participants were members of an elderly care program linked to a state university in Pernambuco and were enrolled in one of the five Workshops on Fall Prevention (WFP) that were offered by the institution between August and December 2011. Thirty older adults were enrolled in each workshop, featuring an initial sample of 150 individuals. Each workshop could have just 30 women.

The eligibility criteria for the research were community-dwelling individuals aged 60 or more, female, diagnosed with T2DM for more than two years and who presented a walking gait without assistive devices. According to professional assessments and data from registration forms, those subjects who had cognitive, orthopedic, neurological and/or vascular deficits, severe visual and/or hearing impairment, foot ulcers, amputations, prostheses and/or physical limitations that would hinder mobility, were excluded from the study.

Data collection was conducted in June and July 2011. The sample selection was carried out by the assessment of 150 records of people enrolled in the five WFP. They were all invited by phone to attend a meeting at the institution where they received information about the research. The subjects who had all the eligibility criteria were invited to participate voluntarily in the research and those with no diagnosis of T2DM formed the control group. After application of the eligibility and exclusion criteria, and respecting the will of each elderly, the final sample was formed by 63 subjects, 33 diabetics and 30 non-diabetics.

The independent variables in this study were: age, falls, physical activity level, dorsal flexion, plantar flexion, and ankle flexibility. In order to characterize the study sample according to these variables, a form was filled out containing the interviewee's identification and the following methodological procedures:

- The participants filled in a questionnaire to investigate and analyze the occurrence of falls in the previous year.

- Assessment of the physical activity level with the International Physical Activity Questionnaire (IPAQ) – short version 8.0. This questionnaire was validated in a Brazilian population. Its short version, an interview concerning the previous week, inquired about the frequency and duration of moderate and vigorous physical activity and also walking, sorting the elderly in four categories: very active (VA), active (AC), irregularly active (IA) and sedentary (SD).{7}

- Ankle's range of motion (ROM): assessed by goniometry of the talo-crural joint by two trained researchers, who used a manual goniometer (Carci®, Brazil). Measurements were taken with active-assisted movements. The dorsiflexion and plantar flexion range of motions were measured bilaterally. The full range of motion, assessed as ankle flexibility, was obtained by adding the mean measurements of dorsiflexion and plantar flexion.{8}

Data analysis was processed using the Software SPSS 15.0. All tests were applied with 95% confidence. The results are presented in table form with their absolute and relative frequencies. Numeric variables are represented by central tendency and dispersion measurements. The Pearson Chi-Square, and Student's t tests were applied.

Results

A flow-chart of the study sample is shown in Figure 1. From a total of 150 records evaluated, 74 (49.33%) individuals were excluded from the study for several reasons. Initially, 25 (16.66%) were male and 22 (14.66%) were not found. During the meeting, 8 (7.76%) met the exclusion criteria and 19 (18.45%) did not attend. From the 76 women who met the inclusion criteria of the survey (50.66%), 13 (17.11%) gave up. The sample was composed of 33 diabetic and 30 non-diabetic elderly women.

The sample general characteristics are presented in Table 1. The elderly had a mean age of 69.43 (±5.59). The mean number of falls in the previous year had been 1.17 (±1.11), and the frequency of falls was 76.19%. Only 26.98% of the sample was sedentary. The mean ankle flexibility was 38.32 (±10.65). The dorsiflexion and plantar flexion means were respectively 13.75 (±5.75) and 24.57 (±7.26) degrees (Table 1). In this study, none of the elderly was classified as active or very active.

The comparative analysis of the frequency of falls in the previous year and the level of physical activity between the two groups showed that both the DG (diabetics group) and the CG (control group) had high frequency of falls and low percentage of sedentariness (Table 2).

Table 3 shows the association of the two groups DG and CG with the variable means: age, falls, ankle flexibility, dorsiflexion, and plantar flexion. The DG mean age was 69.18 (±5.92) and the CG was 69.70 (±5.29), with no difference between groups. The diabetic elderly women had suffered more falls in the previous year ($p \leq 0.05$) and showed a greater reduction of ankle flexibility ($p \leq 0.01$), characterized mainly by a significant decrease in dorsiflexion amplitude ($p<0.001$).

Discussion

The occurrence of falls was high in both groups, DG (66.7%) and CG (86.7%), with no significant difference ($p=0.08$), probably because it is a sample of elderly females willing to attend workshops on fall prevention.

Blank et al.[9] in investigating an interdisciplinary intervention in fall prevention among the elderly in a community, found that falls are common among this population worldwide. In the same vein, Bekibele and Gureje[10] state that falls are a public health problem in many countries, affecting the quality of life of many elderly people. It is important to emphasize that the high incidence of falls in this study may be linked to the fact that the sample consisted of elderly women who were looking for a workshop on fall prevention.

Regarding ankle flexibility, it was observed that in this study there was a significant difference ($p<0.05$) in dorsiflexion (right and left) between CG and DG. In young adults the maximum amplitude of the ankle joint, can, according to Fong et al.[11] and Vianna and Greve,[12] be 20 degrees for dorsiflexion and 52 degrees for plantar flexion. In this study, we observed that in general, both in DG and CG, there was a decrease in ankle range of 31% in dorsiflexion and 50% in plantar flexion, which can be seen as inherent to aging.

The literature reports that, mainly among women, the decrease in muscle strength is more pronounced in individuals over 60, which can interfere in the flexibility of certain joints in the human body.{13}

Although flexibility was decreased in both groups, the diabetics had significantly greater loss of ankle amplitude (dorsiflexion only). Like this article, the study by Saura et al. {14} who assessed the ankle range of motion and the vertical ground reaction forces involved in the gait of diabetic patients with and without peripheral neuropathy, observed that the tibio-tarsal joint amplitude was also diminished in diabetics. Also in this sense, Giacomozzi et al.{15} report that diabetics may have foot motor and sensory disorders and altered gait control, which may interfere in the ankle biomechanics.

The literature also reports that diabetic patients with neuropathy may present muscle weakness and atrophy and changes in the sensory motor region of the foot, which may lead to imbalance, directly interfering in gait neuromuscular coordination and the maintenance of the upright posture.{16}

When checking the level of physical activity performed by the two groups, no statistically significant differences were observed and most of the subjects in both CG and DG were irregularly active. In contrast, Wrobel and Najafi,{17} in his review on the biomechanics of the diabetic foot and gait, report that people with diabetes apparently are less active than individuals without any pathology.

This article has not examined the type of physical activity practiced by the elderly, which may have affected the results, since most physical activities directed at the ankle joint seem, according to Spink *et al.,*{18} directly influence the ankle flexibility and the occurrence of falls.

In this study, the analysis of the number of falls in CG and DG revealed that there was a significant difference, where diabetics had a higher mean number of falls. This fact may be related to a significant decrease in ankle flexibility in this group.

Wrobel and Najafi,{17} in their review on the biomechanics of the diabetic foot and gait, found that diabetic patients tend to take shorter steps with a broad base of support, which directly interferes in balance and can lead to falls.

Araki and Ito,{3} in their review about Diabetes Mellitus and geriatric syndromes, showed that diabetic women have a high risk of falls which can be explained by their balance impairment.

In the same vein, Mecagni et al.{19} assessing the relationship between balance and ankle range of motion in community dwelling healthy women between 64 and 87-years-old, found a strong link between the two variables, specifying the importance of exercise for this joint, which could decrease the risk of falls in this population. Corroborating this research, Menz, Morris, and Lord{5} studying the physical and physiological characteristics of the foot and ankle of 176 elderly subjects of both genders, came to the conclusion that the problems in this region may increase the risk of falls in this population.

In other research, Menz, Morris, and Lord{20} by combining the foot and ankle characteristics with the balance and functional ability of elderly people, found that ankle flexibility and plantar flexor strength directly affect balance and the functional capacity of this population, which may also explain the difference between the two groups.

Melzer et al.{21} found that the plantar flexor muscles are important for balance and stability and that exercises for these muscles can be a tool in fall prevention among the elderly.

Also agreeing with the present study, Morrison et al.[22] conducted a study to evaluate the effects of balance training in elderly patients with T2DM. They state that elderly diabetics have a higher risk of falls compared to individuals without the disease, since they have slower reactions and reduced balance.

Thus, the literature reports that ankle flexibility and falls can be closely related to each other when it comes to individuals over 60 and also in the presence of a chronic disease such as T2DM, which was confirmed in this research.[20,21]

Conlusions

Diabetic elderly women are more prone to recurrent falls and decreased ankle flexibility, particularly dorsiflexion, which is associated with the fall event. Before this picture, further studies are necessary, including randomized clinical trials, as well as prevention strategies and treatment of musculoskeletal disorders of the diabetic patient feet.

Acknowledgments

We thank the whole team that makes up the Elderly Healthcare Nucleus of the Federal University of Pernambuco, Brazil.

Disclosure Statement

The authors did not receive any state funding.

None of the authors have conflicts of interest.

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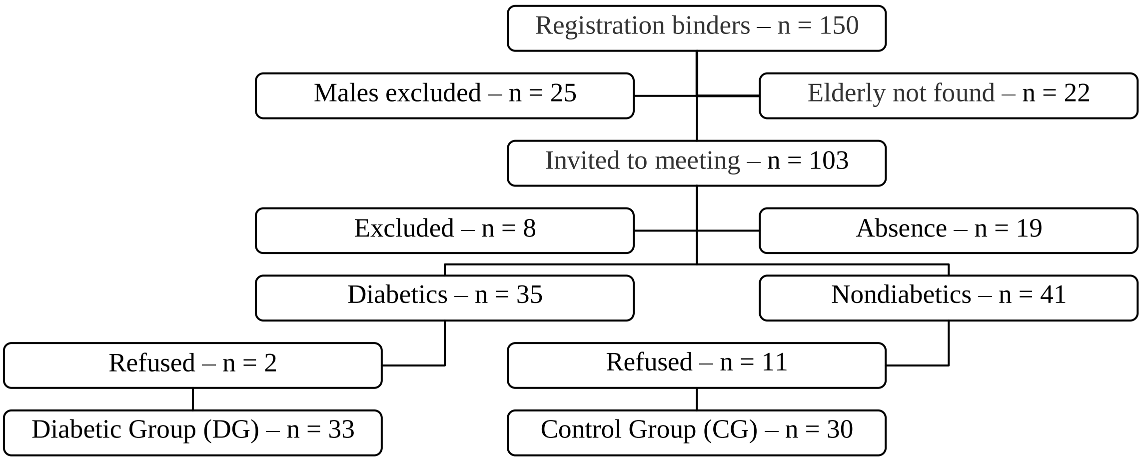

Figure 1 – Flow chart of the study sample.

Table 1 – General Sample Characteristics.

Variables		n	%	Mean	sd
Age (years)		-	-	69.43	5.59
Falls (number)		-	-	1.17	1.11
	FP	48	76.19	-	-
	FA	15	23.81	-	-
Physical activity level (IPAQ)	IA	46	73.01	-	-
	SD	17	26.98	-	-
Ankle flexibility (degrees)		-	-	38.32	10.65
	MDF	-	-	13.75	5.75
	MPF	-	-	24.57	7.26

FP (fall presence), FA (fall absence), IA (irregularly active), SD (sedentary), MDF (mean dorsiflexion – right and left), MPF (mean plantar flexion – right and left).

Table 2 – Comparison of fall frequency and physical activity level between the diabetic (DG) and non-diabetic (CG) groups.

		DG		CG		
Variables		n	%	n	%	p
Falls	FP	22	66.7	26	86.7	0.080
	FA	11	33.3	4	13.3	
IPAQ	IA	25	75.8	21	70.0	0.818
	SD	8	24.2	9	30.0	

DG (diabetic group), CG (control group), FP (fall presence), FA (fall absence), IPAQ (physical activity level), VA (very active), AC (active), IA (irregularly active), SD (sedentary). Pearson Chi-Square test.

Table 3 – Association of the variables age, falls, ankle flexibility, and dorsiflexion and plantar flexion means between the elderly diabetic (DG) and non-diabetic (CG) groups

	DG		CG		
Variables	Mean	sd	Mean	sd	p
Age (years)	69.18	5.92	69.70	5.29	0.722
Falls (number)	1.30	1.16	0.80	0.71	0.046
Ankle flexibility (degrees)	35.06	9.15	41.90	11.18	0.009
MDF (degrees)	11.70	4.57	16.00	6.14	0.003
MPF (degrees)	23.36	7.34	25.90	7.06	0.167

DG (diabetic group), CG (control group), MDF (mean dorsiflexion – right and left), MPF (mean plantar flexion – right and left). Student's test.