
EDUCAÇÃO FÍSICA

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**Intervenções com a atividade física em crianças e adolescentes com
deficiência intelectual: Uma meta-análise**

INTERVENÇÕES COM A ATIVIDADE FÍSICA EM CRIANÇAS E ADOLESCENTES COM DEFICIÊNCIA INTELECTUAL: UMA META-ANÁLISE

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Resumo

Deficiência intelectual é uma condição atípica ao desenvolvimento que envolve problemas em um conjunto de fatores, como as habilidades intelectuais, comportamento adaptativo, interações e papéis sociais, entre outros. Além do que, apresentam maior porcentagem de sedentarismo do que a população em geral, assim como também participam cada vez menos de atividade física regular, à medida que crescem e envelhecem. A participação de pessoas com deficiência intelectual em programas de atividade física promove, além dos benefícios de prevenção de doenças, particularmente cardiovasculares, a melhora da capacidade intelectual e cognitiva. Além disso, a prática regular de atividade física promove redução de gordura corporal. Portanto o objetivo geral deste estudo foi identificar através de uma revisão sistemática, programas de atividade física para adultos com deficiência intelectual e sua extensão quanto aos benefícios, limitações e recomendações e tem como objetivos específicos: analisar os diversos tipos de programas de atividade física e determinar qual é o mais indicado para adultos com deficiência intelectual, além de determinar os benefícios que os programas de exercício físico sistematizado acarretam para adultos com deficiência intelectual. A busca eletrônica inicial resultou em 2808 manuscritos. O processo de análise dos estudos envolveu leitura de títulos, resumos e textos completos verificando os critérios de exclusão pré-determinados. Após todas essas fases, oito manuscritos preencheram os critérios de inclusão da revisão. Os artigos apresentaram participantes de ambos os gêneros com idade entre 18 e 67 anos com deficiência intelectual leve ou moderada. O período de intervenção dos estudos variou de 2,5 meses até 9 meses, com a frequência semanal de uma vez até três vezes por semana. Os tipos de intervenção diferiram entre os artigos analisados, incluindo atividades de lazer e recreação, exercícios combinados de força e resistência muscular, atividades aeróbias de caminhadas, com corridas e em bicicletas ergométricas, atividades generalizadas e especialização esportiva, atletismo e basquete. De modo geral, o exercício físico apresenta benefícios para pessoas com deficiência intelectual melhorando uma série de aspectos relacionados à capacidade física, ao bem estar psicológico, saúde e qualidade de vida. Concluindo, portanto, que qualquer atividade física tem efeitos significativos na vida de adultos com deficiência intelectual, porém, se a intenção é aumentar o benefício do programa de atividade física, a intervenção que combina exercício de força muscular e resistência aeróbia é a mais recomendada para adultos com deficiência intelectual.

Palavras chaves: Deficiência intelectual, atividade física, programas de intervenção.

Abstract

Abstract Intellectual disability is development atypical conditions that involve issues on a number of factors, such as intellectual skills, adaptive behavior, interactions and social roles. Furthermore, they report higher rates of physical inactivity than the general population, as well as participating less and less of regular physical activity, as they grow and age. The participation of people with intellectual disabilities in physical activity programs promotes, benefits of prevention of diseases, particularly cardiovascular, improvement of intellectual and cognitive ability in addition, regular physical activity promotes reduction of body fat. Therefore the aim of this study was to identify through a systematic review, physical activity programs for adults with intellectual disabilities and their extension of the benefits, limitations and recommendations, moreover, the following objectives: to analyze the types of physical activity programs and determine which is the most suitable for adults with intellectual disabilities, and to determine the benefits that physical exercises programs entail for adults with intellectual disabilities. The initial electronic search resulted in 2808 manuscripts. The predetermined exclusion criteria were: review process of the studies involved reading titles, abstracts and full texts checking. After all these phases, eight manuscripts met the inclusion criteria of the review. Articles presented participants aged between 18 and 67 years with mild to moderate intellectual disability. The intervention period was from 2.5 months studies ranged up to 9 months and the weekly frequency was from one to three times a week. The intervention types differ between the articles analyzed, including leisure and recreation activities, combined exercises of strength and muscular endurance, aerobic activities of hiking, with races and exercise bikes, widespread activities and sports specialization, athletics and basketball. Overall, exercise has benefits for people with intellectual disabilities improve a number of aspects related to the physical capacity, psychological well-being, health and quality of life. In conclusion, therefore, that any physical activity has significant effects on the lives of adults with intellectual disabilities, however, if the intention is to increase the benefit of physical activity program, the intervention that combines exercise muscle strength and aerobic endurance is the most recommended for adults with intellectual disabilities.

Key words: Intellectual disability, physical activity, intervention program.

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1 INTRODUÇÃO

A atividade física regular é importante para melhorar a qualidade de vida das pessoas (ACSM'S GUIDELINES FOR EXERCISE TESTING AND PRESCRIPTION, 2000). Apesar de atualmente estarem difundidos os benefícios da prática de atividade física, a sociedade sofre com uma epidemia de problemas de saúde, entre eles destacamos a obesidade. Este quadro torna-se mais agravante quando a composição corporal dos indivíduos é associada a condições de deficiência intelectual. A participação de pessoas com deficiência intelectual em programas de atividade física promove benefícios na capacidade aeróbia, intelectual e cognitiva, na força muscular e na prevenção de doenças, particularmente cardiovasculares (BRYL, MATUSZAK & HOFFMANN, 2013; WEBER E FRENCH, 1988). Entretanto, apesar da literatura mostrar os benefícios de programas de atividade física para a pessoa com deficiência intelectual, a eficiência dos programas para esta população ainda é pouco conhecida. Aspectos relacionados à prescrição, controle de carga, limitações, melhores exercícios, entre outros, especialmente para adultos com deficiência intelectual são os assuntos em espera da investigação científica. Desta forma, esta revisão sistemática pretende responder os seguintes questionamentos: Quais tipos de programas de atividade física são atualmente recomendados para adultos com deficiência intelectual? Quais os benefícios que os programas de atividade física trazem para adultos com deficiência intelectual? Qual/quais tipos de programas de atividade física são os mais eficazes para esta população?

O interesse em programas de atividade física para adultos com deficiência intelectual justifica por si só os estudos com este foco, tornando-se ainda mais relevante quando dados epidemiológicos e gastos anuais relacionados a esta população são acrescentados. Por volta de 2.848.684 (8,3%) da população total do país é composta por deficientes intelectuais (IBGE, 2000). Ainda, a expectativa de vida das pessoas com deficiência intelectual passou de 35 anos, em 1991, para 55 anos, em 2000 (NERI, 2003). Possivelmente muito da melhora da qualidade de vida e o aumento da expectativa de vida advém da evolução no sistema médico e alternativas terapêuticas. Porém, a promoção de atividade física para esta população ainda é um desafio, especialmente aos adultos, o que ocasiona aumento das necessidades médicas decorrentes de sedentarismo e hábitos nutricionais insatisfatórios. De fato, nos EUA, os gastos por pessoa nascida com deficiência intelectual é estimada em 51 bilhões de dólares (CENTERS FOR DISEASE CONTROL AND PREVENTION, 2004

Este estudo enfatiza os benefícios da atividade física de forma geral e os prejuízos para quem não realiza atividade física, principalmente relacionados à obesidade, particularmente da pessoa com deficiência intelectual. Apresentamos a seguir os benefícios que o exercício físico promove na população com deficiência intelectual e as barreiras que esta população enfrenta para realizar atividade física.

1.1 Benefícios da atividade física e prejuízos da falta de atividade física para a população em geral.

Os benefícios motores, físicos e cognitivos advindos da prática regular de atividade física propiciam uma melhor qualidade de vida, principalmente aos fatores relacionados à saúde (ARAÚJO, 2000), como a obesidade, diabetes, hipertensão, entre outros. De fato, a prática regular de atividade física tem sido considerada um fator de proteção contra os processos degenerativos do organismo, atuando como agente promotor da saúde (GUIMARÃES, 1993; BARRETO, PINHEIRO & SICHIERI et al., 2005). Atualmente o exercício físico é reconhecido como uma intervenção eficaz para diversas doenças, sendo indicado no tratamento de grande número de desordens médicas (OLDRIDGE, 2003; ROBERTS & BARNARD, 2005). As evidências científicas comprovam que o exercício físico é tão eficaz quanto o tratamento medicamentoso, podendo até em certas situações ser mais eficaz que este ou contribuir para otimizar seu efeito (PEDERSEN & SALTIN, 2005). Para proporcionar benefícios aos indivíduos, especialistas recomendam a prática de atividade física com uma frequência de 3 a 5 vezes semanais em períodos de 40 a 60 minutos por sessão (dia) e com uma duração longa, de meses ou até contínua, tornando-a eventualmente uma rotina (ACSM, 1998). Porém, o tipo de exercício, duração, intensidade e frequência semanal devem obedecer aos princípios gerais de treinamento e às limitações de cada indivíduo (LAZZOLI et al., 1998).

O objetivo principal da atividade física para adultos é o retardamento do processo do envelhecimento (que afeta a força, flexibilidade e resistência), o controle da composição corporal (peso), além de bem estar físico e mental. O exercício físico regular proporciona melhoras na eficiência do metabolismo, diminuição da gordura corporal e aumento da massa e melhora nos componentes da capacidade física e motora e de funções cognitivas (MACEDO et al., 2003; MATSUDO & MATSUDO, 2000; GOBBI, VILLAR & ZAGO, 2005). Para Ramos (1999), a atividade física produz uma melhora na aptidão física do adulto e principalmente do idoso, ou seja, quanto mais ativa é uma pessoa menos limitações físicas ela

tem. Adultos e idosos ativos exibem níveis de força muito mais elevados do que idosos sedentários (SIMAO, 2004). A atividade física regular melhora os aspectos psicológicos e emocionais, como autoestima, ansiedade e imagem corporal (GONÇALVES, CAMPANA, & TAVARES, 2012; CARRARO & GOBBI, 2012). Em adultos a prática de atividade física promove diminuição de dores articulares, aumento de densidade mineral óssea e do perfil lipídico, melhora da utilização de glicose, aumento da capacidade aeróbia, força muscular e flexibilidade (MATSUDO, 2001). E mais, estudos mostram que o treinamento da resistência, da força e da combinação destes dois componentes tem positiva influência sobre a composição corporal, aptidão física e metabólica, sendo considerado o treinamento ideal (PEDERSEN & SALTIN, 2006).

Apesar de todo o conhecimento apresentado acima referente aos benefícios da atividade física para diversos grupos em variados estágios de desenvolvimento, atualmente a sociedade apresenta uma epidemia de problemas de saúde, entre eles pode-se destacar a obesidade. Fatores sociais, culturais, econômicos e de falta de atividade física são considerados os motivos para a epidemia de obesidade (WHO, 2006). A melhora tecnológica, industrialização e globalização na sociedade contribuíram vertiginosamente para a mudança de hábito da população que, devido às facilidades do mundo atual, diminuiu a prática de atividade física e aumentou o consumo de alimentos calóricos e de atividades sedentárias (BRAGGION, MATSUDO & MATSUDO, 2000). Para se observar o tamanho do problema, recentemente, o Ministério da Saúde divulgou uma pesquisa onde mostra que quase metade da população brasileira está acima do peso, sendo 48,5% da população composta de obesos (VIGITEL, 2011). Este quadro torna-se mais agravante quando a composição corporal de adultos com deficiência intelectual é incluída (RAULINO E BARROS, 2002). A prática de atividade física desde a infância torna mais provável que uma criança fisicamente ativa venha a se tornar um adulto também ativo (DUNCAN, DUNCAN & STRYCKER, 2005). Em consequência, do ponto de vista de saúde pública e medicina preventiva, promover a atividade física na infância e na adolescência e dar continuidade na vida adulta significa permite estabelecer uma base sólida para a redução da prevalência do sedentarismo na idade adulta, contribuindo desta forma para uma melhor qualidade de vida e redução no número de obesos (LAZZOLI et al., 1998).

1.2 A pessoa com deficiência intelectual

Deficiência intelectual é uma condição atípica ao desenvolvimento que envolve problemas em um conjunto de fatores, como as habilidades intelectuais, comportamento adaptativo, interações e papéis sociais, entre outros (CARVALHO E MACIEL, 2003). Luckasson e colaboradores (2002) definem a deficiência intelectual como: limitações significativas no funcionamento adaptativo expresso nas atividades práticas, sociais e conceituais, originando-se antes dos 18 anos de idade. O aparecimento da deficiência intelectual ocorre devido diversos fatores relacionados à genética, problemas na gestação, principalmente relacionados ao desenvolvimento do cérebro, anóxia ou hipóxia ocorridas durante o parto, e doenças pós-natais (MAUERBERG-DECASTRO, 2011). Os deficientes intelectuais apresentam características diferentes da população em geral. Eles têm uma tendência à depressão e isolamento, desenvolvimento cognitivo mais lento, problemas de atenção, dificuldade de memória de curto prazo e 2 a 4 anos de atraso no desenvolvimento motor (MAUERBERG-DECASTRO, 2005).

Indivíduos com deficiência intelectual apresentam maior porcentagem de sedentarismo do que a população em geral (DIXON-IBARRA et al., 2013), assim como também participam cada vez menos de atividade física regular à medida que crescem e envelhecem (EMERSON, 2005, FREY, BUCHANAN & ROSSER, 2005, MESSENT, COOKE & LONG, 1999, YAMAKI, 2005). Somente um pequeno número dessa população atinge a meta recomendada semanalmente de atividade física (USDHHS, 2008). A vida sedentária deste grupo de pessoas tem levado cada vez mais ao aparecimento de problemas de saúde como colesterol alto, hipertensão e problemas cardiovasculares (RIMMER & YAMAKI, 2006, CHASSLER FREEDMAN, 2004, DRAHEIM, 2006). Raulino e Barros (2002) indicaram que a propensão de indivíduos com deficiência intelectual em desenvolver obesidade é maior do que os indivíduos sem deficiência intelectual. Os autores relataram em seu estudo que 28% dos homens e 38% das mulheres com deficiência intelectual leve (quociente de inteligência entre 53 e 70) e moderada (quociente de inteligência entre 36 a 52) foram considerados obesos. Além disso, a elevada incidência em indivíduos com síndrome de Down na população com deficiência intelectual mostra que uma em cada oito pessoas é obesa (RAULINO & BARROS, 2002; SILVA, 2006). A obesidade em deficientes intelectuais é prejudicial uma vez que, além de acarretar em maior possibilidade de doenças, afeta também as atividades diárias, particularmente do controle postural (LUCENA, 2011).

1.3 Atividade física e o deficiente intelectual

Estudos relatam que o treinamento de força e resistência tem um leve efeito positivo sobre a composição corporal (peso, índice de massa corporal e massa gorda) e um efeito maior na resistência cardiovascular e resistência muscular de pessoas com deficiência intelectual (CALDERS et al., 2011; CARMELI et al., 2005; SHIELDS, TAYLOR & DODD, 2008; MENDONÇA, PEREIRA & FERNHALL, 2011; MAUERBERG-DECASTRO, 2013). A participação em programas de atividade física promove para as pessoas em geral, além dos benefícios de prevenção de doenças, particularmente cardiovasculares, estimula indiretamente a capacidade intelectual e cognitiva (BRYL, MATUSZAK & HOFFMANN, 2013). A prática regular de atividade física também promove redução de gordura corporal (ORDOÑEZ, ROSETY & ROSETY-RODRIGUEZ, 2006), benefícios na capacidade aeróbia, especialmente no tempo para atingir a exaustão (VARELA, SARDINHA & PITETTI, 2001; MILLAR, FERNHALL & BURKETT, 1993), melhoras na força muscular (WEBER E FRENCH, 1988), diminuição na frequência cardíaca, e aumento da potência anaeróbia (LEWIS E PINKHAM, 2005). Quando essas atividades são incorporadas na infância e continuam até a vida adulta, e mantêm os níveis ideais de exigências relacionados ao gasto energético, os efeitos negativos do processo de envelhecimento precoce podem ser atenuados (MAUERBERG-DECASTRO, 2011).

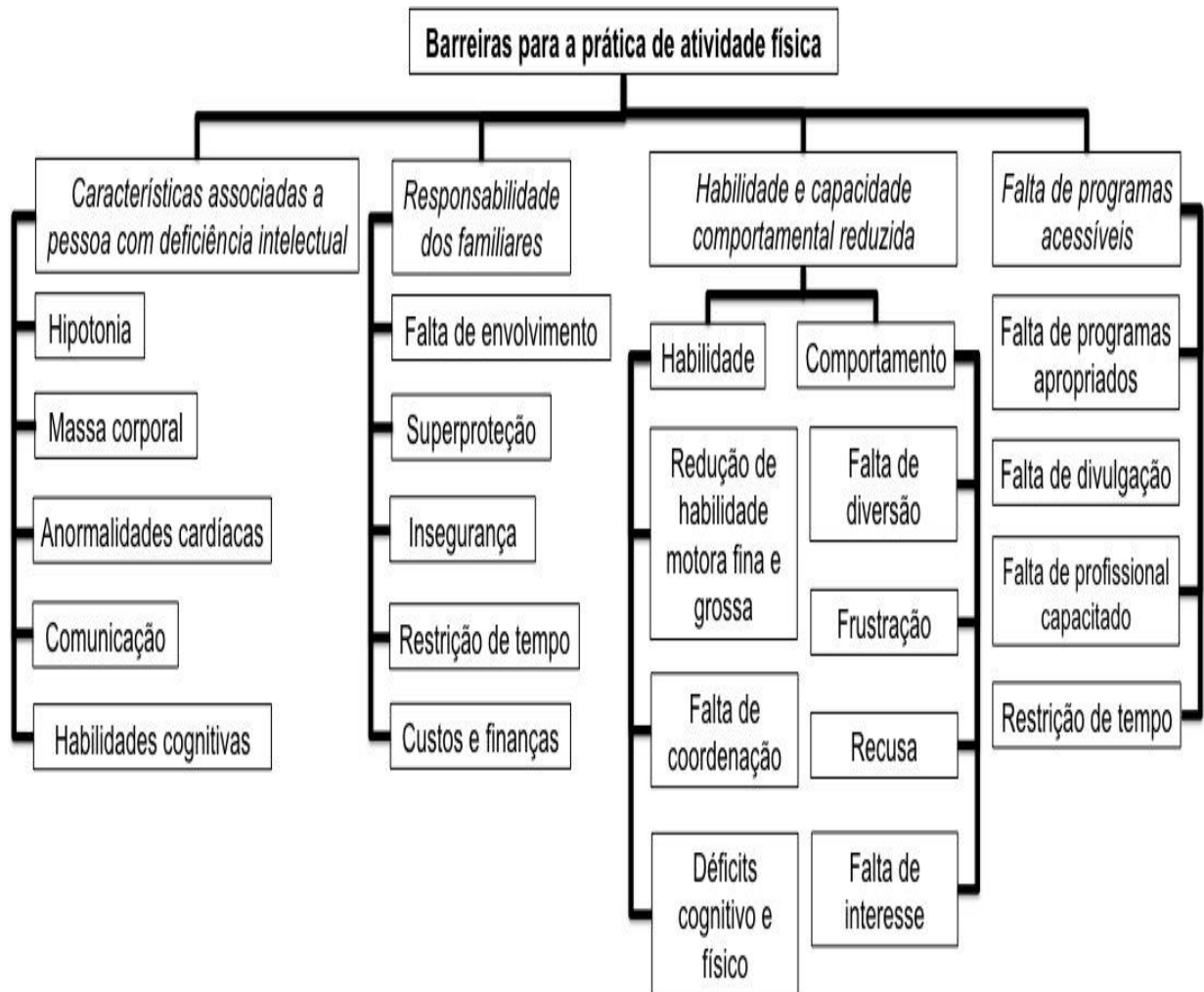
Indivíduos com deficiência intelectual apresentam menor nível de atividade física que indivíduos saudáveis (FREY, 2004; DRAHEIM, WILLIAMS, & MCCUBBIN, 2002; MESSENT, COOKE, & LONG, 1998; TEMPLE, FREY, & STANISH, 2006). Entretanto, indivíduos com deficiência intelectual, dentro de seu potencial biológico, podem realizar todo tipo de atividade física, seja através das atividades desenvolvimentistas, de esporte ou de lazer (MAUERBERG-DECASTRO, 2013). De maneira geral, seja qual for o contexto da estimulação, a meta do profissional de atividade física adaptada com deficientes intelectuais é proporcionar um meio de desenvolvimento geral e a manutenção ou recuperação da saúde (MAUERBERG-DECASTRO, 2011). Com isso, os princípios de volume (que pode ser caracterizado como máxima participação nas atividades e aumentado de forma gradativa) e intensidade (acima de 70% da frequência cardíaca máxima) devem ser incorporados nos programas de atividade física para deficientes intelectuais. Apesar de parecer uma atividade física rotineira, de acordo com González-Agüero e colaboradores (2010), questões a respeito da duração e intensidade do programa de atividade física e quais tipos de exercícios são mais indicados para adultos com deficiência intelectual ainda não foram respondidas e necessitam de estudos mais aprofundados sobre como melhorar a eficácia na prescrição de exercícios. Ainda, programas de longa duração apresentam igualmente limitações devido à dificuldade de

controle de carga e avaliações (BAQUET et al., 2006; KEMPER et al., 2001). Finalmente, devido à confusão na prescrição e procedimentos, os programas de atividade física apresentam uma série de limitações na estruturação de programas de educação física na escola e instituições (MAUERBERG-DECASTRO, 2011).

1.4 Barreiras para a prática de atividade física de deficientes intelectuais

Além das características da deficiência intelectual, existe uma série de barreiras para a prática de atividade física com este grupo, como por exemplo, suporte negativo e falta de incentivo de cuidadores e professores, limitações financeiras, falta de transporte, falta de opção e falta de políticas públicas claras para que haja o engajamento significativo desses alunos com a atividade física regular. A falta de suporte educacional e conhecimento sobre os benefícios da atividade física em geral, falta de conhecimento e prática de professores e instrutores, tédio ou frustrações por conta de atividades desestimulantes, medo por conta das condições físicas e superproteção familiar tornam o problema mais complexo ainda (WINICK & SHORT, 2000). Essas barreiras prejudicam a participação desses indivíduos em programas de atividade física e aumentam a prevalência de sedentarismo e obesidade entre eles. Na Figura 1 são apresentadas as barreiras de acordo com as características das pessoas com deficiência intelectual, responsabilidade dos familiares, capacidade física desta população e falta de programas de atividade física acessíveis.

Figura 1. Esquema representando as barreiras e limitadores na prática de atividade física para pessoas com deficiência intelectual.



Fonte: adaptado de BARR & SHIELDS, (2011).

2 OBJETIVOS

O objetivo geral deste estudo é, através de uma revisão sistemática, identificar programas de atividade física para adultos com deficiência intelectual e sua extensão quanto aos benefícios, limitações e recomendações.

2.1 Objetivos específicos

- Analisar os diversos tipos de programas de atividade física e determinar qual é o mais indicado para adultos com deficiência intelectual;
- Determinar os benefícios que os programas de exercício físico sistematizado acarretam para adultos com deficiência intelectual.

3 MÉTODO

Para identificar os artigos que realizaram programa de exercício físico com deficientes intelectuais, primeiramente definimos as bases de dados que integraram esta revisão sistemática. As bases de dados analisadas foram: PubMed, EBSCOhost, Web of Science e Scopus (principais bases de dados da área de Educação Física). Uma busca eletrônica nestas bases foi realizada incorporando referências publicadas entre janeiro de 1960 até agosto de 2014. A pesquisa criteriosa nos principais jornais da área, autores frequentemente citados e listas de referência dos artigos aumenta as chances de localizar artigos relevantes para uma revisão de literatura compreensiva. Para ser relevante nesta revisão sistemática, o artigo deveria ser em inglês e apresentar as seguintes palavras-chave: atividade física (physical activity) ou aptidão física (physical fitness) ou exercício físico (physical exercise) ou condição física (fitness); deficiência intelectual (intellectual disability) ou deficiência mental (mental disease) ou retardo mental (mental retardation); programa de atividade física (physical activity program) ou programa intervenção (intervention program). Inicialmente foram utilizadas todas estas palavras chaves em conjunto, utilizando o comando “and” e “or” para ordená-las. Em seguida, estas palavras foram agrupadas em duas ou três, por exemplo, physical activity and intellectual disability and physical activity program. Além disso, os termos na estratégia de busca foram também pareados, por exemplo, intellectual disability or mental diseases. Os termos foram buscados no título, resumo e nas palavras-chave dos manuscritos. Além disso, foi realizada busca manual por artigos que não estavam nestas bases eletrônicas, por exemplo, estudos citados por outros manuscritos. Estudos que envolvessem animais, robôs, metodologia qualitativa e revisões sistemáticas foram excluídos da análise. Ainda, a busca limitou-se a artigos que estudaram indivíduos adultos (acima de 18 anos). Além disso, estudos que não relataram adequadamente o programa de atividade física aplicado foram excluídos. Finalmente, artigos que se enquadravam nos critérios de exclusão e inclusão deste estudo, mas que não foram acessados na versão integral (não disponibilizado eletronicamente ou em papel ou solicitado aos autores mas não enviados) também foram excluídos.

Os artigos identificados pela estratégia de busca inicial foram avaliados conforme a seguinte estratégia de busca:

- estudos controlados randomizados com adultos a partir dos 18 anos de idade com deficiência intelectual que incluíam programas de atividade física (definida com um planejamento sistemático de ações empregados em um tempo e local específico, designado para promover mudança de comportamento entre os participantes da intervenção - Conn et al., 2001);
- envolver a seguinte deficiência intelectual de origem cromossômica: síndrome de down;
- envolver deficiências intelectuais de etiologia ambiental ou desconhecida que tenha por efeito atraso no desenvolvimento global;
- apresentar grupo experimental, considerado como o grupo onde os participantes receberam a intervenção mais intensa, e grupo controle, que recebeu cuidados habituais ou alguma forma de atenção ou indivíduos que não apresentam deficiência intelectual;
- haver avaliação antes e após o programa de atividade física para demonstrar a eficiência e aplicabilidade do programa.

A triagem inicial foi realizada através da combinação de todos os artigos originais encontrados nas bases de dados eletrônicas analisadas (artigos que apareciam em duas ou mais bases de dados). Os artigos não relacionados com o tema desta revisão sistemática foram excluídos durante uma triagem secundária de títulos e resumos. Os resumos dos artigos restantes foram confrontados com os critérios de inclusão/exclusão. Quando o resumo não continha informações suficientes, o texto completo foi examinado para decidir sobre a inclusão. A estratégia de busca foi realizada independentemente por dois pesquisadores. Os artigos foram analisados na íntegra por meio de roteiro estruturado com a contemplação dos seguintes itens: amostra (tipo de deficiência e idade dos participantes do estudo), delineamento da pesquisa, metodologia utilizada, tipo de intervenção realizado no estudo, efeitos (benefícios) encontrados, limitações e recomendações. Os resultados dos dois revisores foram cruzados para verificar a concordância e os resultados discordantes foram resolvidos por consenso.

Os artigos selecionados para esta revisão sistemática foram apresentados em tabelas e os dados de interesse foram agrupados em tópicos de acordo os itens do roteiro estruturado.

4 RESULTADOS

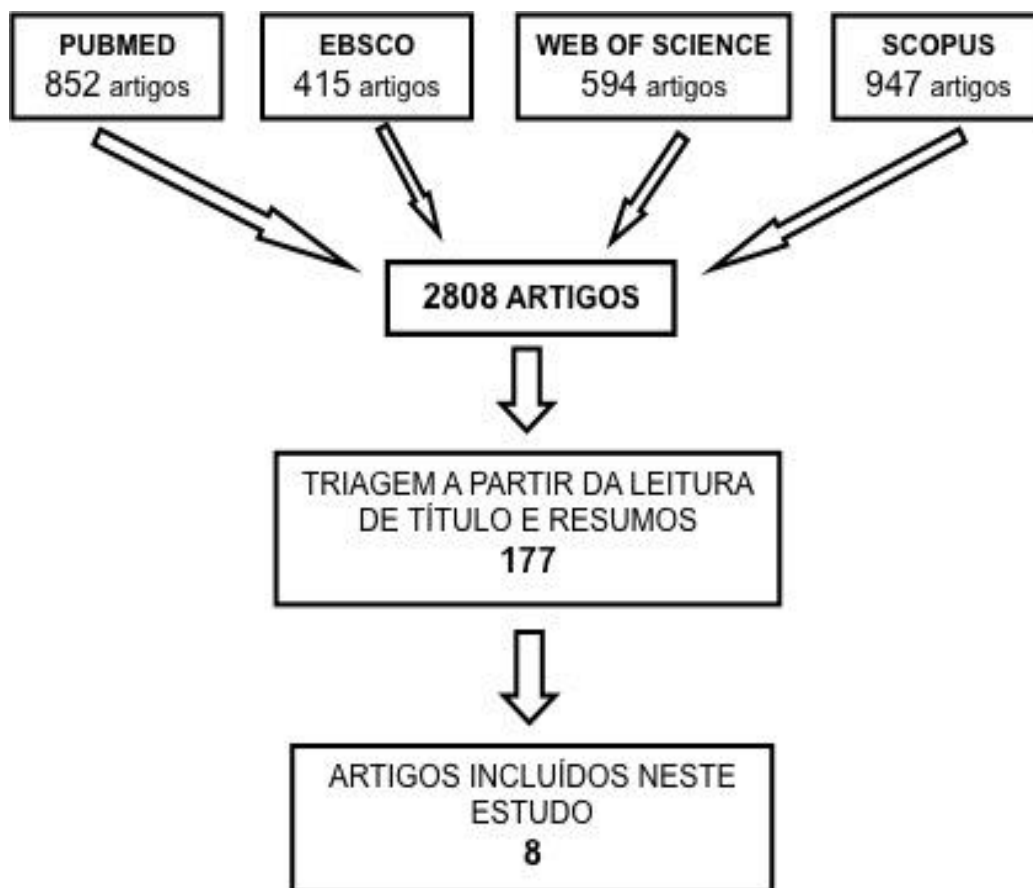
4.1 Números da busca por artigos

Através da busca inicial realizada foi possível identificar 2808 artigos científicos relacionados ao assunto desta revisão sistemática. Após a revisão do título e do resumo dos artigos selecionados encontrou-se 177 artigos relataram sobre o efeito do exercício físico para pessoas com deficiência intelectual. Após a leitura criteriosa na íntegra dos artigos, foram selecionados 8 estudos para compor esta revisão sistemática, que se encaixaram em todos os critério determinados pelo estudo.

Foram excluídos os estudos que envolviam uma população com idade inferior a 18 anos; que não tivesse grupo controle, que não realizasse pré- e pós-teste e que não descreviam as intervenções com especificidade.

A Figura 2 apresenta um resumo dos estágios da busca dos artigos.

Figura 2. Fluxograma da seleção dos artigos incluídos na revisão sistemática. O número abaixo dos textos indica o número de artigos originais (não duplicados) em cada estágio de busca.



4.2 Características da amostra dos estudos

Os artigos apresentaram participantes de ambos os gêneros com idade entre 18 e 67 anos, sendo que na maior parte dos estudos apresentaram como amostra adultos entre 20 e 50 anos com deficiência intelectual leve ou moderada. Interessantemente, 3 estudos (CARMELI et al, 2003 e 2005; CALDERS et al, 2011) analisaram o efeito de um programa de exercício físico em pessoas com deficiência intelectual com mais de 60 anos. Nenhum estudo verificou o efeito do exercício físico ao longo do processo de envelhecimento na fase adulta ou comparou o efeito de intervenção entre adultos e idosos. Apenas 4 estudos (SHIELDS, TAYLOR & DODD, 2008; CARMELI et al., 2009; CALDERS et al, 2011; CARRARO & GOBBI, 2012) apresentaram um grupo de pessoas com deficiência intelectual que não realizaram exercício físico ou realizaram as atividades diárias normalmente durante o período

do estudo. Ainda, apenas 2 estudos (CARMELI et al., 2003; MENDONÇA, PEREIRA & FERNHALL., 2011;) apresentaram um grupo controle de pessoas sem deficiência intelectual.

4.3 Duração do programa de exercício físico

O período de intervenção dos estudos foi de 2,5 meses até 9 meses, com a frequência semanal de uma vez até três vezes por semana. Quatro estudos (CARMELI et al., 2003, 2005 e 2009; CARMELI et al., 2009; GUIDETTI et al., 2010) apresentaram efeito de um programa de exercício por mais de 5 meses, com frequência de 3 vezes por semana e sessões de pelo menos 30 minutos. A duração das sessões variou entre 20 minutos até 120 minutos de exercício. Apenas um estudo (SHIELDS, TAYLOR & DODD, 2008;) não relatou a duração da sessão de exercício, uma vez que o tempo de realização dos exercícios musculares determinados para a sessão é quem determinavam a duração da sessão.

4.4 Tipos de intervenção

Os tipos de intervenção diferiu entre os artigos analisados, incluindo atividades de lazer e recreação (CARMELI et al., 2009; GUIDETTI et al., 2010; CARRARO & GOBBI, 2012), exercícios combinados de força e resistência muscular (SHIELDS, TAYLOR & DODD, 2008; CARMELI et al., 2009; GUIDETTI et al., 2010; CALDERS et al., 2011; MENDONÇA, PEREIRA & FERNHALL, 2011;) atividades aeróbias de caminhadas, com corridas e em bicicletas ergométricas (CARMELI et al., 2003 e 2009; CALDERS et al., 2011), atividades generalizadas (CARMELI et al., 2009; CARRARO & GOBBI, 2012) e especialização esportiva, atletismo e basquete (GUIDETTI et al., 2010). A seguir foi descrito de modo geral o que compunha cada um destes tipos de exercício.

- 1) Atividades de lazer e recreação: foram jogos recreativos, relaxamento, atividades com bolas bobath, atividades com corda, jogos adaptados, exercícios de respiração, brincadeiras até arte manuais como pintura.
- 2) Exercícios combinados de força e resistência muscular: envolviam exercícios de força máxima, com 1 repetição apenas (1RM) e de resistência muscular sendo o número de repetições a 50% do peso de 1RM ou séries de 10 a 15 repetições de cada aparelho ou movimento, repetindo-se duas vezes cada série. Os principais aparelhos e movimentos realizados foram: leg press, agachamento com e sem peso, flexão e extensão dos joelhos, exercícios de panturrilha com e sem peso, tração vertical, flexão e extensão do cotovelo

principalmente para bíceps, flexão e extensão do braço principalmente para tríceps (push down), adução e abdução de ombros para peito, abdução e adução de pernas, pack deck e variadas formas de abdominal.

3) Atividades aeróbias: as atividades de caminhadas variaram entre 15 a 35 minutos, sendo individualizado a velocidade realizada pelos participantes. Para as corridas não foi especificado a duração e intensidade, porém eram corridas intervaladas com outros exercícios, não caracterizando uma corrida contínua de longa duração (apenas 5 a 10 minutos). Na bicicleta ergométrica as atividades duravam entre 15 e 35 minutos, porém, também não houve descrição da velocidade ou intensidade.

4) Atividades generalizadas: eram realizados movimentos corporais gerais como sentar e levantar, flexão de tronco, rotação pélvica, movimentos de braço, andar, posturas de estabilização corporal, exercícios de flexibilidade sem uso de pesos nas posições de decúbito ventral e dorsal e rotação do corpo.

5) Especialização esportiva: atividades relacionadas aos componentes da capacidade física, as como força, resistência aeróbia, velocidade, flexibilidade e coordenação e o treinamento de uma modalidade esportiva, atletismo ou basquete no caso dos estudos pesquisados.

Tabela 1. Descrição dos artigos que realizaram um programa de atividade física para pessoas com deficiência intelectual. DI – deficiência intelectual.

Autores	Objetivo do artigo	Amostra dos estudos	Duração e tipos de intervenção	Benefícios	Conclusão estudo
Calders et al. (2011)	Comparar o efeito do exercício combinado de capacidade aeróbia e força muscular com o exercício de capacidade aeróbia e sem exercício em pessoas com DI.	45 pessoas com DI 18 a 60 anos	2x sem: 5 meses (70 min) G1: exercício de força muscular e aeróbio G2: exercício aeróbio G3: atividade da vida diária	- G1 maiores benefícios que G2 para G3 - G1 maior força muscular, capacidade aeróbia pressão arterial que G2 após intervenção.	Exercício combinado parece ter mais efeito na população de pessoas com DI do que somente exercícios aeróbios.
Carmeli et al. (2003)	Determinar os efeitos do exercício terapêutico no equilíbrio em pessoas com DI.	29 pessoas com DI 50 a 67 anos	3x sem: 6 meses (30 min) G1: exercícios dinâmicos na bola e caminhada na esteira G2: pessoas com DI sem intervenção GC: sem intervenção	Nenhum benefício para equilíbrio estático e dinâmico após a intervenção.	Exercício terapêutico não melhora o equilíbrio de pessoas com DI.
Carmeli et al. (2005)	Investigar o efeito do exercício físico no equilíbrio, força muscular e bem estar geral em pessoas com DI.	22 pessoas com DI 54 a 66 anos	3x sem: 6 meses (40-45 min) G1: exercício força muscular e equilíbrio G2: exercícios generalizados	- G1 e G2 melhora bem estar geral. - G1 melhora no equilíbrio e força muscular que G2 após intervenção.	A prática de exercício tem efeitos psicológicos (melhora do humor e autoconfiança) de pessoas com DI. O exercício específico em força muscular e equilíbrio têm mais benefícios para DI que exercício generalizados.
Carmeli et al. (2009)	Determinar os efeitos do exercício físico na ansiedade e qualidade de vida em pessoas com DI.	24 pessoas com DI 45 a 50 anos	3x sem: 6 meses (20-40 min) G1: exercício aeróbio G2: atividade de lazer G3: sem exercício	- G1 e G2 melhora a ansiedade após intervenção. - G3 sem melhora da ansiedade após intervenção.	Exercício aeróbio e atividade de lazer reduzem a ansiedade e a qualidade de vida de pessoas com DI.

G1: Grupo um; G2: Grupo dois; G3: Grupo três; GC Grupo Controle.

Continuação Tabela 1

Autores	Objetivo do artigo	Amostra dos estudos	Duração e tipos de intervenção	Benefícios	Conclusão estudo
Carraro; Gobbi (2012)	Investigar o efeito do exercício na ansiedade em pessoas com DI.	27 pessoas com DI 31 a 49 anos	1x sem: 3 meses (120 min) G1: exercício generalizados G2: sem exercício	G1 melhora a ansiedade para G2 após intervenção.	Programa de exercício generalizado de curta duração promove melhora da ansiedade de pessoas DI.
Guidetti et al. (2010)	Comparar o efeito do treinamento de atletas com pessoas que realizam atividade recreacional ou de lazer em pessoas com DI.	41 atletas com DI 23 não atletas com DI 18 a 45 anos	3x sem: 9 meses (60 min) G1: exercício para capacidade física e modalidade esportiva (atletismo ou basquete) G2: atividade de lazer e recreação	G1 melhora equilíbrio, força muscular, coordenação e agilidade para G2 após intervenção.	A atividade esportiva promove melhora na capacidade física de pessoas com DI em comparação a atividade de lazer e recreacional.
Mendonça; Pereira; Fernhall (2011).	Verificar o efeito de um programa de exercício combinados na capacidade física de pessoas com DI.	13 pessoas com DI 12 GC 27 a 50 anos	3x sem: 3 meses (30min) DI e GC: exercício de resistência muscular e aeróbio	Ambos os grupos melhoram a capacidade física similarmente após exercício.	Exercício combinado induz melhora semelhantes entre pessoas com DI e GC.
Shields; Taylor; Dodd (2008).	Determinar o efeito do exercício progressivo aeróbio na força e resistência muscular em pessoas com DI.	20 pessoas com DI 20 a 49 anos	2x sem: 2,5 meses G1: exercício progressivo de resistência muscular GC: atividade da vida diária	- G1 melhora resistência muscular de membros inferiores que GC após intervenção. - G1 e GC são semelhantes para força muscular de membros inferiores após intervenção.	Exercício progressivo de resistência muscular melhora a resistência muscular de membros inferiores de pessoas com DI, necessitando de maior tempo de intervenção para melhorar força muscular.

G1: Grupo um; G2: Grupo dois; G3: Grupo três; GC Grupo Controle.

4.5 Benefícios dos programas de exercício físico

De modo geral, o exercício físico apresenta benefícios para pessoas com deficiência intelectual. Apenas um estudo não apresentou benefício do programa de atividade física, talvez por conta da baixa frequência de intervenção, sendo apenas uma vez por semana. Os programas de atividade física melhoram uma série de aspectos relacionados à capacidade física (força muscular, capacidade aeróbia, equilíbrio, coordenação, agilidade), ao bem estar psicológico (ansiedade), saúde (gordura corporal, pressão arterial) e qualidade de vida de pessoas com deficiência intelectual.

5 DISCUSSÃO

O principal objetivo desta revisão sistemática foi identificar programas de atividade física para adultos com deficiência intelectual e determinar os benefícios que os programas de exercício físico sistematizado acarretam para esta população. Nossa revisão de sistemática mostrou um limitado número de estudos que investigou, de forma estruturada, o efeito de programas de atividade física para adultos com deficiência intelectual. De modo geral, nenhum dos estudos desenvolveu um programa de atividade física específico para a população em questão, sendo utilizados programas para pessoas sem deficiência intelectual com determinadas adaptações às restrições individuais da população em questão deste estudo. Além disso, os estudos envolveram adultos e idosos com deficiência intelectual no mesmo grupo, sem haver uma comparação entre as idades. Finalmente, parece não haver um consenso de que tipo de intervenção utilizar para promover a prática de atividade física de adultos com deficiência intelectual. Nos próximos parágrafos iremos discutir as três questões que nortearam este estudo: Quais os tipos de programas de atividade física para adultos com deficiência intelectual? Quais os benefícios que os programas de atividade física trazem para adultos com deficiência intelectual? Qual/quais tipos de programas de atividade física são os mais eficazes para esta população?

5.1 Quais os tipos de programas de atividade física para adultos com deficiência intelectual?

Os estudos apresentaram uma série de programas de atividade física para adultos com deficiência intelectual. Três tipos de programas de atividade física para adultos com deficiência intelectual foram os mais indicados na busca por benefícios na qualidade de vida desta população: exercícios combinados de força e resistência muscular, atividades aeróbias e especialização esportiva. Ainda, efeitos de atividades generalizadas, atividades terapêuticas, recreacionais e de lazer também foram analisados pelos estudos para a população em questão. Entretanto, estes últimos não foram eficazes para pessoas com deficiência intelectual, pois realizaram intervenções de curta duração e apenas uma ou duas vezes por semana, além de serem atividades pouco estruturadas e em sua maioria com pouca movimentação. Somente a atividade generalizada parece ser indicada para benefícios em aspectos psicológicos, como humor, autoconfiança e ansiedade de adultos com deficiência intelectual (CARMELI et al.,

2003, 2009). Desta forma, a seguir são apresentadas explicações sobre a escolha destes três tipos de intervenções para esta população.

O programa de atividades aeróbias melhora o VO_2 de adultos com deficiência intelectual, beneficiando a capacidade aeróbia, a economia de movimento e aspectos psicológicos, como a ansiedade (MENDONÇA, PEREIRA & FERNHALL, 2011). Com relação aos benefícios na capacidade aeróbia e economia de movimento, o programa de atividades aeróbias aumenta a funcionalidade das enzimas mitocôndrias específicas do sistema muscular, promovendo benefício nestes aspectos para esta população (MENDONÇA, PEREIRA & FERNHALL, 2011). Já para a ansiedade, pesquisas anteriores mostram que o exercício aeróbia afeta o funcionamento do cérebro, influenciando neurotransmissores no sistema nervoso central, como dopamina, serotonina, entre outras, que são responsáveis por regular o humor, e consequentemente, os aspectos psicológicos (FERNHALL et al., 1990; MENDONÇA & PEREIRA, 2008). Desta forma, esta é uma das intervenções mais recomendadas para adultos com deficiência intelectual, apesar de promover poucos benefícios em outros aspectos da capacidade física, como por exemplo, força muscular, como relatado por estudos anteriores (SHIELDS, TAYLOR & DODD, 2008).

O programa de exercícios combinados de força e resistência é indicado para pessoas com deficiência intelectual por promover benefícios sobre o sistema nervoso periférico, auxiliando na redução da frequência cardíaca e redução da pressão arterial (CALDERS et al., 2011; DINARDI, 2003). Ainda, exercícios de força muscular promovem benefícios no equilíbrio, na estabilidade postural, na agilidade, na flexibilidade, na densidade mineral óssea, na massa muscular e no bem estar (SILVA, 2006; CARMELI et al., 2005; CALDERS et al., 2011; MENDONÇA, PEREIRA & FERNHALL, 2011; SHIELDS, TAYLOR & DODD, 2008). Além disso, os exercícios aeróbios deste tipo de intervenção promovem todos os benefícios apresentados para a intervenção anterior. Desta forma, a combinação destes dois tipos de intervenção parece ser capaz de beneficiar adultos com deficiência intelectual de forma semelhante aos adultos sem deficiência, havendo melhoras na força muscular e na capacidade aeróbia numa taxa de mudança similar (MENDONÇA, PEREIRA & FERNHALL, 2011). Entretanto, de forma interessante, o exercício de força muscular não foi recomendado como única intervenção para pessoas com deficiência intelectual, sendo sempre combinado com outro tipo de exercício. Este parece indicar que o exercício de força é benéfico para aspectos físicos e de composição corporal, mas pouco para aspectos psicológicos. Com isso, o exercício combinado parece ser uma intervenção interessante para adultos com deficiência intelectual.

A especialização esportiva parece ser indicada para adultos com deficiência intelectual por promover benefícios na habilidade motora e aspectos sociais. Esportes coletivos são indicados por estudos anteriores como uma atividade interessante para adultos com deficiência intelectual por desenvolver os aspectos físicos e motores e principalmente por incorporar o relacionamento social através das relações interpessoais (GUIDETTI et al., 2009; GUIDETTI et al., 2010). Esportes individuais, como a corrida, melhoram o equilíbrio e aspectos cardiovasculares que são ruins em pessoas com deficiência intelectual (CARMELI et al., 2005; CARBONARO, MERNI & MADELLA, 2000). Desta forma, a especialização esportiva apresenta influencia positiva na capacidade física de adultos com deficiência intelectual.

5.2 Quais os benefícios que os programas de atividade física trazem para adultos com deficiência intelectual?

Todo programa de atividade física, independente se para adultos com deficiência intelectual ou não, traz benefícios para aspectos relacionados à qualidade de vida dos indivíduos. No entanto, a partir desta revisão sistemática pode-se identificar que os benefícios dos programas de atividade física foram dependentes da intensidade, volume e tipo da atividade proposta.

Com relação à intensidade, programas de atividade física com intensidade maior foram mais bem sucedidos que os programas de atividade física com intensidade menor, por exemplo, programas que envolviam atividade recreacionais e de lazer. A intensidade da atividade física é um importante componente para se atingir os benefícios do programa de exercício físico. Aspectos como bem estar, ansiedade, autoconfiança e humor podem ser beneficiados por programas de exercício físico de baixa intensidade (CARMELI et al., 2009; GUIDETTI et al., 2010; CARRARO & GOBBI, 2012). No entanto, aspectos da capacidade física e especialmente relacionados à saúde somente responde após intervenções que atinjam determinado grau de intensidade. Por exemplo, estudos mostram que a hipertensão arterial somente tem benefício do exercício físico quando a atividade é em torno de 70% do consumo máximo de oxigênio, por pelo menos três vezes por semana e com duração superior a 30 minutos (LESNIAK & DUBBERT, 2001; RONDON & BRUM, 2003). Desta forma, programas de exercício que não têm preocupação com a intensidade das atividades pode não promover o benefício esperado.

Para o tipo de intervenção obviamente que os programas de atividade física trouxeram benefícios de acordo com o objetivo propostos, por exemplo, exercícios com o objetivo de melhorar força muscular, melhoravam força muscular e não outro aspecto. No entanto, o benefício de cada tipo de programa de atividade física para adultos com deficiência intelectual parece ser dependente do volume da intervenção. Quando o objetivo proposto pelo programa é melhorar aspectos psicológicos, como ansiedade, apenas uma vez por semana de exercício parece ser suficiente para melhorar o bem estar do indivíduo, enquanto que para melhoras dos aspectos da capacidade física, como força muscular e capacidade aeróbia, é necessário um programa com maior frequência semanal (duas ou três vezes). Ainda, o tempo da sessão deve ser controlado. Estudos que apresentaram período curto nas sessões, por exemplo, três vezes por semana por 20-40 minutos em cada sessão (CARMELI et al., 2009), encontraram efeito apenas para aspectos psicológicos. Estudos que realizaram o mesmo número de sessões por semana, mas por um período maior, por exemplo, 70 minutos (CALDERS et al., 2011), obtiveram além de melhoras psicológicas, também melhora na capacidade física e aspectos da saúde. Uma possível explicação é que programas de atividade física que não atingem as recomendações da ACSM (1998), atividade física de 3 a 5 vezes semanais com duração mínima de 40 minutos, não são capazes de promover mudanças metabólicas nos indivíduos.

5.3 Qual/quais tipos de programas de atividade física são os mais eficazes para adultos com deficiência intelectual?

Obviamente cada tipo de programa de atividade física promove benefícios específicos de acordo com o objetivo do programa. É possível notar nesta revisão que, com uma única exceção (CARMELI et al., 2003), todos os programas atingiram seus objetivos seja de forma mais ou menos consistente. Desta forma, é difícil determinar qual é o programa de atividade física mais eficaz para adultos com deficiência intelectual. No entanto, se for observada a quantidade de benefícios promovidos pelo programa de atividade física, aparentemente programas de atividade física que combinam força muscular e resistência aeróbia são mais eficazes que os outros programas para adultos com deficiência intelectual. Os benefícios que este tipo de programa de atividade física promove parece ser maior que os outros programas promovem, melhorando outros aspectos que não são objetivos deste tipo de intervenção. Como apresentado no tópico 5.1, é provável que a combinação dos efeitos dos dois tipos de atividades envolvidas promova esta mudança mais eficaz para esta população.

5.4 Limitações

Apesar de achados consistentes, o estudo apresenta algumas limitações. Primeiro, ainda não é claro como deve ser a formatação de um programa de atividade física para adultos com deficiência intelectual. Apesar da qualidade dos artigos incluídos nesta revisão sistemática, muitas dúvidas surgem com relação à maneira que as atividades foram desenvolvidas. Desta forma, recomenda-se que futuros estudos esclareçam as estratégias de desenvolvimento das atividades nesta população não somente o produto final. Segundo, não há uma normalização com relação à inclusão de grupo controle sedentário de pessoas com deficiência intelectual ou grupo controle de pessoas sem deficiência intelectual. Mesmo com critérios bem definidos dos estudos, o uso deste tipo de grupo pode mascarar os resultados. Assim, uma padronização neste sentido pode ser bem vinda. Terceiro, alguns estudos incluíram adultos e idosos com deficiência intelectual no mesmo grupo de pesquisa. Desta forma, estes estudos ignoraram o efeito do envelhecimento nas variáveis analisadas, sendo recomendado para futuros estudos que esta análise seja feita separadamente, estudando apenas adultos ou idosos com deficiência intelectual. Finalmente, apesar de benefícios evidentes não há uma sistematização dos programas de atividade física para adultos com deficiência intelectual. Com isso, recomenda-se que futuros estudos sistematizem programas específicos para pessoas com deficiência intelectual que provavelmente irão aumentar os benefícios encontrados para esta população.

6 CONCLUSÃO

De forma geral, qualquer atividade física tem efeitos significativos na vida de adultos com deficiência intelectual, principalmente porque em sua grande maioria são pessoas sedentárias que não praticam a quantidade mínima recomendada de atividade física. No entanto, se a intenção é aumentar o benefício do programa de atividade física para esta população, pode-se concluir que a intervenção que combina exercício de força muscular e resistência aeróbia é a mais recomendada para adultos com deficiência intelectual. Ainda, pode-se concluir que intervenções que envolvem exercícios aeróbios, especialização esportiva e combinação de exercício de força muscular e aeróbios realizados 2 ou 3 vezes por semana por mais de 40 minutos trazem benefícios para diversos aspectos da qualidade de vida de adultos com deficiência intelectual, sendo os mais recomendados para esta população.

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Anexos

Article

 **CLINICAL
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Effect of combined exercise training on physical and metabolic fitness in adults with intellectual disability: a controlled trial

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Abstract

Objective: Investigating the effect of combined aerobic and strength training on metabolic and physical fitness in adults with intellectual disabilities compared to endurance training and no training.

Design: A controlled trial with patients receiving either combined (COM), endurance (END) or no training (C).

Setting: Two centres for intellectual disabilities (Sterrenhuis, Brasschaat and Emiliani, Lokeren, Belgium).

Subjects: Forty-five adults with intellectual disabilities (mean age: 42 (9,2), mean body mass index (BMI): 24 (3,9), mean IQ: 56 (5,6)).

Intervention: Combined exercise training ($n = 15$) and endurance training ($n = 15$) twice a week for 70 minutes per session for 20 weeks and no training ($n = 15$). Groups were matched for age, sex and intellectual disability.

Main measures: Lipid profile, physical fitness (primary); blood pressure and body composition.

Results: Compared to no training, combined exercise training has significant positive effects on total cholesterol levels, aerobic capacity, muscle strength and resting systolic blood pressure, while endurance exercise training has significant effects on aerobic capacity and resting systolic blood pressure. Compared to endurance training, combined exercise training resulted in a significant better evolution of total cholesterol (mean differences: -18 versus -3 mg/dl), 1RM upper ($+6$ versus $+1$ kg) and lower limb ($+25$ versus $+8$ kg) and abdominal muscles ($+15$ versus $+1$ kg), hand grip strength ($+9$ versus $+2$ kg), muscle fatigue resistance ($+11$ versus $+5$ sec), sit-to-stand ($+5$ versus $+2/30$ sec) and systolic blood pressure (-15 versus -10 mmHg).

Conclusion: This study revealed a tendency towards more beneficial effects of combined exercise training in adults with intellectual disability.

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Introduction

It has been well documented that adults with intellectual disabilities have suboptimal levels of cardiovascular fitness compared to persons without intellectual disabilities.^{1,2} Several reasons for these impaired fitness are a sedentary lifestyle, associated pathophysiological problems, like hypotonia, mitochondrial dysfunction and an increased prevalence of congenital cardiovascular diseases.^{3,4} The decreased muscle strength, aerobic capacity, fat-free mass and the increased fat mass are associated with an unfavourable lipid profile and increased resting blood pressure.^{3,5} As a consequence, this population has an increased risk for obesity, diabetes and cardiovascular disease.^{6,7}

Regular physical activity seems to be a key stone in the prevention and treatment of this increased risk profile. In adults without intellectual disabilities, it has been proven that endurance training, strength training and combined endurance and strength training have a positive influence on body composition, physical and metabolic fitness, with the combined mode as the most optimal.⁸⁻¹⁰

Concerning the effects of supervised training programmes in persons with intellectual disabilities, most of the reported data focused on endurance training with a small positive effect on body composition (weight, body mass index (BMI), fat mass, fat free mass) and large positive effects on cardiovascular endurance (peak oxygen consumption, peak ventilation, peak exercise capacity, time to exhaustion) and muscle endurance.¹¹⁻¹⁷ Few studies focused on strength or resistance exercises with a small positive effect on body composition (increased fat free mass) and muscle strength (1RM, hand grip strength).¹⁸⁻²⁰

Concerning combined exercise training Heller²¹ and Rimmer²² reported on the same

sample after a combined cardiovascular (30 minutes) and strength exercise (15 minutes) training for 12 weeks, three days a week for 45-minutes per session in 53 adults with Down's syndrome (M age = 39.7 years) a significant improvement in endurance and muscular strength and a slight but significant reduction in body weight.

In these studies only the combined exercise training method was compared with a control group and not with another training method. From these results it is only possible to evaluate if exercising is positive, but not if one method is more beneficial to another. In addition, the sample consisted only of Down's syndrome adults. They have a specific pathophysiological profile and it is not possible to generalize to a larger population with intellectual disability. Data evaluating the effect of exercise training on lipid profile in adults with intellectual disability are not available, but in children and adolescents, Elmaghoub²³ reported beneficial effects of a combined exercise training programme compared to no training.

Due to the above mentioned arguments, the purpose of this study is to investigate the influence of combined endurance and strength training on indices of body composition, resting blood pressure, lipid profile and physical fitness in adults with intellectual disabilities. Furthermore, using a controlled approach we aim to compare this training mode with endurance training to investigate the most beneficial training mode.

Material and methods

Seventy adults with intellectual disabilities from two centres for intellectual disabilities (Sterrenhuis, Brasschaat and Emiliani, Lokeren, Belgium) were eligible to participate

in the study. People were included when they were between 18 and 60 years, with a total IQ between 45 and 70 and were excluded if they had any severe neurologic or orthopaedic impairments and were not taking any medication that may adversely influence their physical response to exercise. They were living in group home situations and were able to communicate and understand verbal and/or visual instructions. From these adults, 45 people were selected so three groups of 15 participants could be matched for age, sex and IQ. If three people with the same age, sex and IQ were available, they were randomly allocated to one of the three groups was done. The experimental groups were the combined exercise training group which attended a combination of strength and

endurance exercises twice a week for 40 sessions (20 weeks) and the aerobic exercise training group which attended endurance training twice a week for 40 sessions (20 weeks). These groups were compared with a control group (normal daily activities) (Figure 1). Participants were diagnosed as Fragile X syndrome ($n=18$), fetal alcohol syndrome ($n=6$), Prader Willi syndrome ($n=6$), hydrocephalus ($n=3$), pervasive development disorder ($n=3$), Sotos syndrome ($n=3$) and Down's syndrome ($n=3$). From three patients we were unable to retrieve the cause of mental retardation. In several participants autism ($n=24$) or mild epilepsy ($n=12$) was associated with the intellectual disability. Written informed consent (signed by parents or tutor and adults themselves) was obtained from

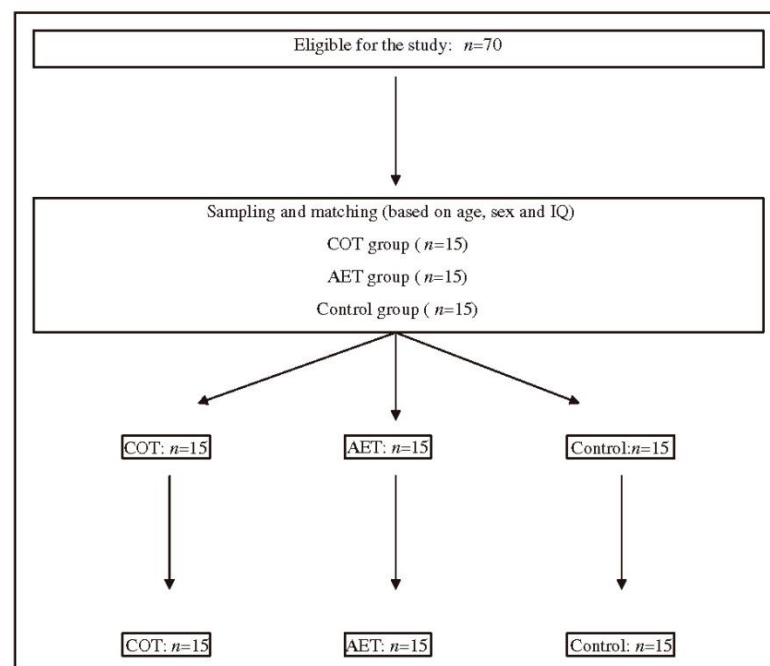


Figure 1. Participants' flow diagram depicting that no subjects dropped out during the trial. AET, aerobic exercise training; COT, combined exercise training.

Table 1. Influence of combined endurance and strength training twice respiratory three times a week on indices of anthropometry and lipid profile in adults with intellectual disabilities

Variables	COT (n = 15)		AET (n = 15)		Control (n = 15)	
	Pre	Post	Pre	Post	Pre	Post
General data						
Age (y)	42 (7.5)		42 (9.3)		43 (11.4)	
Gender						
(female/male)	9/6		9/6		9/6	
IQ	56 (4.3)		58 (3.9)		53 (5.3)	
Anthropometry						
Weight (kg)	66.9 (12.23)	67.7 (13.16)	70.9 (14.53)	70.4 (14.70)	65.1 (11.50)	65.1 (10.55)
Length (m)	167 (9.9)	166 (10.3)	166 (10.7)	166 (9.5)	171 (13.5)	170 (14.0)
BMI (kg/m ²)	24.0 (3.92)	24.3 (4.19)	25.7 (4.10)	25.3 (4.72)	22.3 (3.42)	22.9 (3.25)
Waist (cm)	87 (10.9)	87 (9.6)	90 (12.7)	91 (12.7)	81 (9.8)	83 (8.2)
Fat mass (kg)	29 (10.6)	28 (10.2)	30 (8.3)	29 (7.3)	26 (5.7)	27 (8.0)
Fat-free mass (kg)	38 (14.0)	42 (15.5)	40 (15.7)	41 (15.7)	39 (11.4)	38 (15.5)
Blood pressure						
SBD (mmHg)	140 (15.4)	125 (9.1)*§	131 (15.3)	120 (14.0)*	126 (14.9)	134 (14.7)
DBD (mmHg)	84 (52.0)	82 (39.0)	80 (29.0)	80 (20.0)	75 (33.8)	73 (24.8)
Lipid profile						
Total chol. (mg/dl)	194 (39.7)	176 (36.1)*§	196 (38.8)	193 (34.9)	194 (35.2)	199 (27.0)
HDL (mg/dl)	55 (12.9)	59 (12.6)	52 (10.4)	55 (12.6)	54 (10.5)	54 (9.7)
LDL (mg/dl)	117 (42.6)	116 (32.4)	117 (34.0)	116 (31.2)	122 (20.3)	122 (23.4)

Data are presented as mean (standard deviation). Repeated measures ANOVA with *post hoc* Bonferroni was used to evaluate time and interaction effects. AET, aerobic exercise training; BMI, body mass index; COT, combined exercise training; DBD, diastolic blood pressure; HDL, high-density lipoprotein; IQ, intelligence quotient; LDL, low-density lipoprotein; SBD, systolic blood pressure; Total chol., total cholesterol.

* $p < 0.05$ significant different evolution COT v Control or AET v Control

§ $p < 0.05$ significant different evolution COT v AET

There are no significant differences found at baseline.

the participants. Approval for this study was provided by the ethics committees of the University Hospital Ghent. General characteristics of the participants are described in Tables 1 and 2.

The combined exercise training group followed a 20-week training programme (40 sessions) containing strength and endurance exercises. The adults exercised twice a week for 70 min per session. The training sessions were integrated in the daily programme and were supervised by two physiotherapists.

Each training session included warming up (5 min), cycling (10 min), strength training of

the biceps brachii and triceps brachii (10 min), stepping (10 min), strength training of quadriceps and hamstrings (10 min), running (10 min), functional training of abdominal and back muscles (10 min) and cooling down (5 min).

The aerobic part of the training (cycling, stepping, running) involved individually prescribed exercise regimens starting at 90% of the ventilatory anaerobic threshold (VAT) which increased up to 100% after 10 sessions and to 110% after 20 sessions. The participants used stationary bicycles, cross trainers and a treadmill.

Table 2. Influence of combined endurance and strength training twice respiratory three times a week on indices of physical fitness in adults with intellectual disabilities

Variables	COT (n = 15)		AET (n = 15)		Control (n = 15)	
	Pre	Post	Pre	Post	Pre	Post
Physical fitness						
PeakVO ₂ (L/min)	1.85 (0.716)	2.07 (0.660)*	1.86 (0.729)	1.90 (0.683)	1.84 (0.561)	1.72 (0.649)
Rel. peak VO ₂ (ml kg ⁻¹ min ⁻¹)	27.7 (10.03)	30.3 (10.08)*	26.2 (8.92)	26.9 (6.87)	28.5 (8.68)	26.3 (9.72)
Peak power (Watt)	124 (49.5)	138 (51.9)*	127 (38.9)	132 (42.9)*	134 (32.0)	133 (43.7)
Peak HR (#/min)	155 (14.1)	154 (10.8)	163 (17.2)	158 (18.3)	166 (13.6)	158 (16.6)
6 MWD (m)	502 (109.8)	557 (121.4)*	519 (81.7)	545 (83.1)*	558 (68.4)	545 (71.7)
IRM UL (kg)	30 (3.9)	36 (6.4)*§	29 (7.5)	30 (6.9)	28 (8.5)	26 (3.9)
IRM LL (kg)	75 (18.0)	100 (22.0)*§	70 (35.2)	78 (32.5)	83 (29.3)	74 (25.6)
Abdominal muscle (kg)	32 (18.0)	47 (37.9)*§	34 (30.0)	35 (35.2)	29 (37.3)	27 (35.7)
Low back muscle (kg)	38 (25.0)	43 (29.1)	29 (42.2)	37 (33.2)	35 (35.0)	31 (34.2)
Hand grip (kg)	20 (23.0)	29 (36.1)*§	25 (11.1)	27 (23.2)	22 (21.0)	23 (23.2)
Muscle fatigue resistance (sec)	24 (8.3)	35 (13.3)*§	24 (19.3)	29 (22.5)*	29 (17.5)	29 (16.1)
Sit-to-stand (#/30sec)	15 (6.2)	20 (5.6)*§	15 (2.1)	17 (2.5)	16 (3.3)	15 (2.8)

Data are presented as mean (standard deviation). Repeated measures ANOVA with *post hoc* Bonferroni was used to evaluate time and interaction effects. IRM LL maximal strength lower limb (sum of quadriceps and hamstrings; bilateral); IRM UL maximal strength upper limb (sum of biceps and triceps; bilateral); 6MWD, 6-minute walk distance; AET, aerobic exercise training; COT, combined exercise training; peakVO₂, peak oxygen consumption; peak HR, peak heart rate.

**p* < 0.05 significant different evolution COT v Control or AET v Control

§*p* < 0.05 significant different evolution COT v AET

There are no significant differences found at baseline.

Strength exercises were performed using appropriate fitness equipment (vertical traction, chest press, leg extension and curl, abdominal muscle trainer). Functional exercises for low back muscles were bridging in supine position, ball bridging and unilateral bridging (bridging with extension of the left/right leg). Intensity of strength training was calculated from the one-repetition maximum (1 RM) values. The starting level was 20 RM (two sets of 15 repetitions), which progressed up to 15 RM (two sets of 12 repetitions) after 10 sessions and to 10 RM (three sets of eight repetitions) after 20 sessions. The last set of repetitions was executed until exhaustion and between two sets; a resting period of 60 seconds was observed.

The endurance training group followed a 20-week training programme (40 sessions) containing only endurance exercises. The

participants exercised twice a week during 70 min per session. The training procedure was similar to the combined exercise training group, except for the strength components which were replaced by endurance components such as cycling, stepping, walking/running. The same intensity thresholds and time points were used to build up the training programme as in the combined exercise training group.

The subjects in the control group participated in daily activities without supervised exercise training.

The measurements of the examined variables were performed by blinded assessors. They examined the participants without being aware of the programme followed by each individual.

Before and after the training programme lipid profile and physical fitness (primary outcome),

blood pressure and anthropometric data (secondary outcome) were registered.

Height was measured to the nearest 0.1 cm using a stadiometer (Holtain Ltd., UK). Weight was measured to the nearest 0.1 kg on a digital balance scale (Seca, maximum 200 kg, Germany) with the subject wearing lightweight clothing and no shoes. BMI was calculated from weight and height. Waist circumference was measured by a tape measure at the level of the umbilicus. Body composition was assessed by bio-impedance (Bodystat 1500 MDD). Subjects were in supine position for at least 5 min. Surface electrodes were attached to the dorsal side of the right foot and the dorsal side of the right wrist. Fat mass and fat-free mass were calculated using the formula of Kyle.²⁴

Blood pressure was measured with a manual sphygmomanometer while seated on a chair after measurements of body composition and before the complete physical test procedure started.

Blood samples were obtained after overnight fasting. The following variables were evaluated using diagnostic kits (Roche Diagnostics) for high-density lipoprotein (HDL)-C (PEG + cholesterol-oxidase), triglycerides (glycerol phosphate-PAP) and total cholesterol (cholesterol-oxidase-PAP). Low-density lipoprotein (LDL)-C was calculated from total cholesterol and HDL-C.

In order to evaluate the aerobic capacity, participants performed a maximal cardiopulmonary exercise test on a computer-driven cyclo-ergometer (Marquette Case, Marquette Electronics, Milwaukee, WI, USA) using a gradual protocol starting at 30 W with gradual increase of 15 W every minute.²³ Twelve-lead electrocardiogram and heart rate were recorded continuously during the test, whereas blood pressure was measured with a manual sphygmomanometer every 2 min. Subjects were encouraged to perform exercise testing to the self-determined limits of their functional capacities or until the physician stopped the test because of severe adverse events.²⁵ Respiratory gas measurements were obtained using a Metalyzer 3B

(Cortex, Germany). The oxygen consumption (VO_2), carbon dioxide production (VCO_2), minute ventilation, tidal volume, respiratory rate and mixed expiratory carbon dioxide concentration were measured continuously by mixed chamber analysis. Peak VO_2 was expressed as the highest attained VO_2 during the final 30 seconds of exercise. In order to determine VAT, we plotted ventilatory equivalents (VE) for O_2 and CO_2 . The point at which VE/VO_2 increased without an increase in VE/VCO_2 was accepted as the VAT.²⁵

All patients performed a standardised, self-paced 6-minute walk test (6MWT) in a 20-metre long corridor. They were asked to cover as much distance as possible within 6 minutes without running. Patients were allowed to stop at any time but were encouraged to restart as soon as possible. During the test, patients were instructed and encouraged continuously. Covered distance after 6 minutes was measured to the nearest metre. In a recent reproducibility and validity study (Elmaghoub. *Disabil Rehabil* 2010 submitted) we found that the reproducibility in this population is relatively high with an intraclass correlation coefficient (ICC) = 0.82 and validity (association between 6-minute walk distance and peak VO_2 measured by cyclo-ergometer test) is strong with a Pearson r -value of 0.79.

One-repetition maximum was determined bilaterally with the indirect Holten method using commercial available strength-training equipment (Steens, Belgium) for biceps brachii, triceps brachii, quadriceps and hamstrings. For back and abdominal muscles flexion and extension devices of the Tergumed Line (Proxomed, Germany) were used. A physiotherapist defined for each patient a test weight so that patients would be able to achieve six to 12 repetitions at the most. From this number of repetitions, the 1 RM was calculated using the Holten diagram. The Holten diagram relates the number of repetitions to the percentage of maximum strength.²³ A global score for upper limb strength was calculated by adding up the biceps brachii and triceps brachii scores.

Similarly, a score for the lower limb was found by adding up the quadriceps and hamstrings scores. This test provides a valid and reproducible way to assess strength and changes in strength.²⁶

The sit-to-stand test measures the maximum number of repetitions within 30 seconds an individual is able to rise to a full stance from a seated position on a chair, without pushing off with the arms. The number of completed stances (up down) was considered the participant's score. This test is developed in a population of older adults and is highly correlated with strength of the lower limbs.²⁷

Hand grip strength of the participant was evaluated in a standing position, arms in 90° flexion alongside the body. The participant was asked to squeeze the dynamometer (Jamar) with as much force as possible, being careful to squeeze only once for each measurement. Three trials were made with a resting period of about 10–20 seconds between the efforts to minimize the effects of muscle fatigue. For the same reason, left and right hand were alternated. Only the best score was registered. It has been reported that the hand grip strength has a high reliability in adults with intellectual disabilities with an ICC for dominant and non-dominant hands of 0.96 and 0.94 respectively.²⁸

Muscle fatigue resistance of the participant was measured in the same position as described for the hand grip strength. This time, the subject had to squeeze the dynamometer with as much force as possible and as long as possible. The test was finished when grip strength dropped to 50% of its maximum during sustained contraction.²⁹

Data are expressed as means and standard deviations. Data are analyzed with a commercially available statistical software program (Statistical Package for the Social Sciences, SPSS 15.0, SPSS, Chicago, IL, USA). To evaluate significant time (pre-post differences within groups) and interaction effects (different evolutions between groups) a repeated measure ANOVA *post hoc* Bonferroni test is performed. Significance level is set at $P < 0.05$. To measure effect sizes Cohen's d was calculated. Effect sizes

of 0.2 to 0.3 were classified as 'small' effects, around 0.5 as 'medium' effects and 0.8 to infinity, as 'large' effects.³⁰

Results

Groups were matched for age, gender and IQ. At baseline, there were no significant differences between the groups for cause of intellectual disability, associated disorders, weight, length, BMI, waist, fat mass, fat-free mass, LDL, HDL, total cholesterol, 1 RM upper and lower limb, hand grip strength, muscle fatigue resistance, sit-to-stand test, 6MWT, (relative) peak oxygen consumption, peak power and peak heart rate (Tables 1 and 2).

There was a high programme compliance and a low number of adverse effects were observed. All participants performed a minimum of 36 and a maximum of 40 training sessions within the 20 weeks. Adverse events depending on the exercise programme were very rare and mild (mainly musculoskeletal complaints at the level of the lower limb). Occasionally, the training programme had to be interrupted for one week (two training sessions) due to illness (three subjects).

After training, there were no significant differences for weight, height, BMI, fat mass, fat free mass and waist within or between the three experimental groups (Table 1).

After the training programme systolic blood pressure was significantly decreased in the combined exercise training group ($P = 0.012$) as well as in the endurance training group ($P = 0.024$), compared to the evolution in the control group (no significant changes). Furthermore, the decrease in the combined exercise training group was significantly larger compared to the endurance training group ($P = 0.03$). There were no significant effects for diastolic blood pressure within or between the three experimental groups (Table 1).

Concerning the lipid profile, there were no significant effects on HDL or LDL within or between the three experimental groups. However, total cholesterol was significantly decreased in the combined exercise training

group ($P = 0.01$), while in the endurance training and control groups no significant changes were observed (Table 1).

Effect sizes for cardiovascular risk factors were medium to large as expressed by the Cohen's d for total cholesterol (0.5) and systolic blood pressure (1.2).

After 20 weeks of combined exercise training, (relative) peak oxygen consumption ($P = 0.015$), peak power ($P = 0.02$), six-minute walk distance ($P = 0.008$), 1 RM of upper limb ($P = 0.013$) and lower limb ($P = 0.003$), upper abdominal muscles ($P = 0.03$), hand grip strength ($P = 0.012$), muscle fatigue resistance ($P = 0.024$) and sit-to-stand performance ($P = 0.021$) increased significantly compared to no significant changes in the control group. After endurance training only peak power ($P = 0.021$), six-minute walk distance ($P = 0.03$) and muscle fatigue resistance ($P = 0.026$) increased significantly compared to no significant changes in the control group.

Changes in the combined exercise training group in 1 RM upper ($P = 0.01$) and lower limb ($P = 0.01$) and upper abdominal muscles ($P = 0.03$), hand grip strength ($P = 0.025$), muscle fatigue resistance ($P = 0.03$) and sit-to-stand performance ($P = 0.03$) were significantly different from the evolution in the endurance training group.

Effect sizes (combined exercise training compared to endurance training) were small for peakVO₂, relative peakVO₂, peak power (Cohen's $d = 0.3$; 0.26 resp. 0.29), medium for six-minute walk distance, strength of abdominal muscles, hand grip strength (Cohen's $d = 0.49$; 0.50 resp. 0.31) and large for strength upper and lower limb, muscle fatigue resistance and sit-to-stand (Cohen's $d = 1.13$; 1.85; 1.01 resp. 0.91).

Discussion

Our data indicate no significant effects on body composition. This is in line with other data published concerning endurance training in people with intellectual disability.^{2,11-13,15-18}

Nevertheless, after combined exercise training Heller²¹ and Rimmer²² reported a slight, though significant decrease of body weight in people with Down's syndrome. Our population contained a mixed group of diagnoses and associated problems including Down's syndrome. It is therefore possible that the population we tested is less homogenous compared to the studies of Heller²¹ and Rimmer.²² Another possible explanation is given by Hagobian³¹ based on adult men and women without intellectual disabilities who completed four bouts of exercise while energy-regulating hormones and appetite were measured. In both sexes appetite was increased and the level of energy-regulating hormones altered in a way that stimulated energy intake. It is possible that our population compensated with more eating resulting in no decrease of body weight and alteration of body composition.

Concerning the effects on blood pressure, we found a significant decrease of systolic blood pressure after combined exercise training and endurance training, with a larger impact of the first training mode. The beneficial effect of physical training (endurance, strength and/or combined exercise training) on resting blood pressure in people without intellectual disabilities is well documented with the most beneficial effect after combined aerobic and strength training and in those with hypertension.³²⁻³⁴ In people with intellectual disabilities no data are available. In this population, however, the prevalence of hypertension is larger compared to their peers without intellectual disabilities.⁵ In our population a mixed group of normotensive and hypertensive adults were included.

The antihypertensive effect of exercise is believed to be mediated by reduced sympathetically induced vasoconstriction in the trained state, and decreased catecholamine levels.³⁵ Patients with hypertension often also have dyslipidemia. Physical activity and exercise have beneficial effects on the blood lipid profile in adults without intellectual disability.^{36,37} In our results we see that only in the combined exercise training group there was a significant reduction

of total cholesterol, while in the endurance training group there were no significant differences. Together with the influence on the nervous system, this may explain the larger effect on blood pressure in the combined exercise training group compared to the endurance training group.

Our study only revealed a significant effect on total cholesterol in the combined exercise training group. Data in adults with intellectual disabilities are not available, but in adolescents we could observe a similar medium-sized effect after combined exercise training.²³ In adults without intellectual disabilities positive effects after endurance exercise, strength training and combined exercise training on HDL, LDL and/or total cholesterol were reported.^{8,37,38} Also here it has been observed that the combined exercise training tended to have more positive results.⁹ Pedersen⁸ reported in his meta-analysis that the largest effects were seen in those people who had dyslipidemia. In this study a mixed population of people with dyslipidemia and normal lipid levels were included (normal levels total cholesterol <190 mg/dl; LDL <115 and HDL >40). As we look at the data of the lipid profile in more detail, we see that the levels of HDL were mostly in the normal range. For LDL, and certainly for total cholesterol levels, there were more participants with levels out of the normal range. This could be a possible reason why there is a larger effect on total cholesterol.

Concerning physical fitness, overall significant positive effects were noticed after combined exercise training with the largest effects on the strength components respiratory functional tests compared to endurance training.

Concerning aerobic capacity, only peak power significantly increased after endurance training, whereas peak oxygen consumption did not significantly change. The fact that peak oxygen consumption did not change for a higher level of peak power may indicate an increase in aerobic capacity. These results are supported by several authors.^{2,11,14-16} After combined exercise training, there was a significant increase in

aerobic capacity, expressed as (relative) peak oxygen consumption and peak power. This is in line with the results of Heller²¹ and Rimmer²² who trained adults with Down's syndrome (mean age 39.4 years) for 12 weeks, three days a week for 45 minutes (30 minutes cardiovascular exercise and 15 minutes strength exercise). Comparing combined exercise training with endurance training, combined exercise training tended to have more impact although the difference between both evolutions was not significant. Peak oxygen uptake is determined by the oxygen transport system (pulmonary, cardiac and vascular system) and the oxidative capacity of the skeletal muscle (O₂ use in the mitochondria). The larger impact of combined exercise training on these systems can possibly be explained by the larger impact on the peripheral system after combined training than after endurance training alone.³⁸

The 6 MW distance increased by 55 metres in the combined exercise training group, which is a significant and clinical relevant change.³⁹ Main determinants of this test in patients without intellectual disabilities are strength of quadriceps and peakVO₂.^{39,40} In our study strength of lower limb and more specific quadriceps strength and peakVO₂ in the combined exercise training group indeed increased significantly. Also in the endurance training group an increase of 36 metres in the 6 MW distance was observed. The smaller (though significant) outcome in this training mode can be explained by the smaller impact on quadriceps strength and peakVO₂ of endurance training.

Both upper and lower limb strength and abdominal muscle strength increased in the combined exercise training group, while it remained almost stable in the endurance training and control group. Besides a training effect¹⁸⁻²⁰ there may, however, be an important learning effect leading to this substantial increase. During the first testing and during the training programme, adults learned to perform a correct starting position for every exercise and got acquainted with appropriate technical performance in these exercise tasks. The improved exercise performance

may have contributed to a better score during assessment trials. We found that strength of lower limb muscles ameliorated much more than upper limb muscles. This can be explained by the fact that the training included cycling and stepping exercises besides the strength exercises and thereby addressed lower limb muscles even more explicitly. This is partly supported by the results of the endurance training group with a small, not significant, increase in lower limb strength which can also be explained by the fact that cycling, walking/running and stepping were main components of the programme affecting lower limb muscles.

Hand grip strength and muscle fatigue resistance increased in the combined exercise training group, and these changes were significantly different from the results in the endurance training and control group. The increase of hand grip strength and muscle fatigue resistance can be explained by the increased overall strength. Literature indicates a positive correlation between overall strength and hand grip.²³ Therefore, the increased upper limb strength in our study may also have contributed to the improved hand grip strength. Muscle fatigue resistance is closely related to daily functioning. Muscle fatigue resistance improved in the combined exercise training and endurance training group, while it remained stable in the control group. The positive change within the intervention groups may be explained by the increased muscle strength and a better neurological functioning after the exercise programme as it is stated that these factors, together with psychological factors like emotion and motivation,²⁹ are determinants of fatigue resistance. The better evolution in combined exercise training compared to endurance training can thus be explained by the fact that in the first group there was a significant increase in muscle strength, while in the endurance training group there was no significant change in muscle strength.

Finally, scores on the sit-to-stand test ameliorated in the combined exercise training group. As quadriceps strength is a predictor for sit-to-

stand scores, the increase of lower limb strength in this study can explain the amelioration of sit-to-stand scores in this group.⁴¹

Strengths and limitations of the study

This is the first controlled trial to investigate the effects of combination exercise training in people with intellectual disabilities compared to endurance training and no training. The participants were trained by very competent, experienced and enthusiastic physiotherapists, who carefully guided training and coached test sessions. As a result, we obtained accurate and favourable results, while almost no adverse effects were noticed and a high compliance of the participants was seen.

However, the overall positive outcome must be tempered. A strict randomization of the participants was not possible. For it to be a true randomized controlled trial, every potential participant in the pool would have an equal chance of being allocated or not being allocated into one of the conditions. Due to the fact that strong heterogeneity in this population is present, matching for different criteria is necessary. In this study, groups of three participants based on matching criteria were made. Hereby, not all of the eligible participants had equal chances to be allocated to one of the three groups. This could have biased the experimental groups. The power in this study is relatively low, which means that generalization to a greater population of people with intellectual disability is difficult. The participants who were eligible for the study were those with no severe musculoskeletal, neurological and cardiovascular problems and those willing to participate in the study. The outcome of the study may therefore be influenced by a motivational bias.

Most of the tests used in this study were applied previously in other research programmes within this population, but validity and reliability of, for example 1 RM testing

and tests of muscle fatigue resistance, are not proven for participants with intellectual disabilities. On the other hand, the test results after training were obviously better than before, therefore we can conclude that there is a tendency towards a more beneficial effect of combined exercise training compared to endurance or no training.

Clinical messages

- In people with lifelong severe intellectual disabilities, exercise improves fitness and mobility and reduces some cardiovascular risk factors.
- A combination of strength and endurance training is more effective than endurance training alone.

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In the Public Domain

Five Clinical Tests to Assess Balance Following Ball Exercises and Treadmill Training in Adult Persons With Intellectual Disability

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Background. Incidence rates of falling increase progressively with aging. Preventing or delaying the onset of functional decline is a crucial important goal, because more individuals with intellectual disability (ID) are living well into their sixth and seventh decades. The question of whether walking and ball exercises can effect balance performance has never been reported. This pilot study was conducted to determine the effects of therapeutic training on improving balance capabilities in adults with mild ID.

Methods. The study included 13 women and 4 men, aged 50–67 years (mean age 56.5 years) residing in a residential care center. Five clinical tests were used to determine the “real” picture of the locomotor function and balance before and after the training protocol. Baseline values were determined using 2 control groups of age-matched adults with and without ID. The tests included modified get-up-and-go, full turn, forward reach, sit-to-stand, and one-legged standing. Therapeutic training for 6 months included dynamic ball exercises and treadmill walking with a 2–3% positive inclination.

Results. Participants in the program showed little to no improvement in terms of their static and dynamic balance compared to their initial values. Thus, only 2 of the tests showed statistical significance.

Conclusions. Lack of improvement was noted in both postural and balance control in adults with mild ID as a result of 6 months of intervention by means of ball exercise and treadmill training.

INCIDENCE rates of falling increase progressively with aging (1). Fall-related injuries range from slight contusion to behavioral changes, fractures, coma, and even death (2). Maintaining balance without falling is essential for performing daily activities without injury. Impaired balance in elderly adults in general and in adults with intellectual disability (ID) in particular is problematic (3,4). Professional assessment of the physical capabilities of individuals with ID has led to the development of procedures to detect specific balance impairments and to identify individuals with a greater propensity for falling (5). Although several studies have described the clinical characteristics of balance disorders among aged adults in the general population, relatively little is known about dynamic balance in adults with ID or about the effects of therapeutic training in improving posture and balance (6).

Clinical procedures commonly used to determine levels of physical functioning have 2 main functions: detection of specific impairments and identification of individuals with a greater probability of disease than that found in the general population (7,8). Various clinical assessment methods, including balance testing and isokinetic muscle strengthening, have been successfully used to determine general physical functioning and mobility in the elderly (9–11).

Two main therapeutic physical exercise approaches have been used to improve balance and functional independence: dynamic ball activities (12) and treadmill walking (13).

The main purposes of the present study were to evaluate the effects of 6 months of training with dynamic ball exercises and treadmill walking on improving balance in middle-aged adults with intellectual disability. More specifically, this study also measured the effectiveness and degree of correlation between the 5 different balance tests, thereby determining the “real” functional level as well as ascertaining which of these tests are the most relevant and meaningful.

METHODS

Participants

All participants were residents in a residential care center located in Rechasim, near Haifa, Israel. They all had mild ID requiring minimal supervision for daily activities. The range of their intelligence quotients (IQ range) was 56 to 75 (66 ± 5), as determined using the Stanford Binet Scale (14). Participants included 13 women and 4 men who ranged from 50 to 67 years in age (mean age 56.5 years). An in-house physician referred all participants to the study. None

of the participants had secondary conditions or complications, such as orthopedic disabilities or vestibular, visual, and proprioceptive impairments, that could have made it difficult to perform the training program or the test items. Written informed consent was received from all subjects or their legal guardians prior to participation in the study. Two control groups that did not receive any intervention were used to determine baseline values: Control group A consisted of mild ID volunteers from a similar residential care center located in Hadera, Israel ($n = 12$, mean age 60.3 years). The range of their IQ was comparable with that of the ID group. Control group B consisting of volunteers from a local kibbutz (communal settlement) ($n = 20$, mean age 60.5 years).

Balance Test Procedures

On each occasion, 5 balance tests were undertaken on 3 separate occasions: pretraining (week 0), midtraining (week 12), and posttraining (week 27). On each occasion the 5 different balance tests were performed on separate days during the same week. As far as the authors are aware, there is no existing information that determines correlation among the tests. Each test reflects different functional capabilities and different psychomotor control mechanisms. Each test was performed twice, and the best score was recorded. The experimental rationale to include 5 different tests was (a) to evaluate in which motor area the participants showed greatest improvement following the training program and (b) to evaluate the interclass correlation (ICC) between the various tests. The same rater recorded the measurements, usually at the same time of the day on each occasion.

Timed up-and-go test (TUG).—This test was used to measure a mixture of four different locomotor tasks (modified from the test described by Mathias and colleagues (15). Briefly, participants were asked to rise from a chair, walk 9 meters, turn around, return to the chair, and sit down again. Times were measured using a manual stopwatch. The target time to complete this test for older adults with a good level of independence is between 22 and 26 seconds, as indicated by Wall and colleagues (16), who revised and expanded the test. The advantages of the test are that it is functional, simple, requires simple tools, is quick to perform (under 30 seconds), and can be performed by participants who use walking aids such as a walker, cane, or crutches. The procedure was experimentally tested and found to be a highly reliable tool with a nondisabled aging population to measure a complex chain of the four consecutive movements (17).

Full turn (FT).—The 360° (FT) turn test [described in detail by Berg and colleagues (18)] measures the ability to perform a full turn, with shoes off. The test depends on successful integration between the vestibular–proprioceptive and visual systems. The number of steps and times to complete a full turn in one place and in both directions is recorded on a 5-level graded scale (in seconds), as used by Berg and Norman (19). The validity and reliability of this test was reviewed by Whitney and colleagues (1) and found to be high (ICC 0.83–0.96).

Forward reach (FR).—The FR test [described by Duncan and colleagues (20)] measures the ability of an individual to shift the central of mass of the body by bending forward as far as possible without taking a step. Each participant was given three attempts, and the best score was recorded. Validity and reliability were found to be high (ICC 0.56–0.65) (17).

Sit-to-stand (StS) (Czuka test).—The StS test involves repeatedly getting up from a chair (48-cm height, armless), standing, then sitting again for 20 seconds [as described by Liang and Cameron (21)], and the test measures the ability to transfer body weight upright and then down by use of knee extensor muscles and back muscles.

One-legged standing (OLS).—This test [described by Bohannon (22)] measures the ability to maintain balance while standing still on one leg on a firm floor, with shoes off, eyes open, and crossed arms gripping the shoulders, for 20 seconds. Participants failed the test if any one of the following conditions occurred: touching the floor with the raised leg; trunk swaying across the midline; or arms releasing their grip on the shoulders.

Exercise Activities

All participants participated in the ball exercise and in the walking program 5 days a week for 27 consecutive weeks. However, the first week (week 0), week 12, and the last week (week 27) were designated for completion of balance assessments only. The treadmill program started on the second week (week 1) and continued through week 26, for 3 times a week. From a methodological point of view of gradual progress of the intervention, the ball exercises started only on the third week (week 2) and continued through week 25, twice a week.

Treadmill walking.—A treadmill-walking program was designed to increase walking tolerance and muscle power in individuals. Five minutes of active stretching exercises were undertaken prior to each walking session and included prolonged and progressive stretching of the Achilles tendons, the hamstrings, and the quadriceps muscles. The treadmill program consisted of individually prescribed low-endurance walking at 0% incline, as previously recommended (23,24). The walking distance and speed protocol followed the systematic approach recommended by Fernhall and colleagues (25), which emphasizes heart and respiratory rate. Participants walked on the treadmill 3 times per week for 24 weeks, initially for 5–15 minutes, as tolerated, and then gradually for as long as 30 minutes, with a 2–3% positive inclination of the treadmill as endurance capabilities improved. Participants walked at speeds below the thresholds of breathlessness but as fast as they could comfortably tolerate, and if necessary, participants were allowed to grab the handrails for walking balance adjustments.

Treadmill walking was conducted between 9:30 am and 11:30 am indoors under controlled conditions (23°C, 40% humidity). Monitors stood by the walkers as a safety precaution in case of unexpected dizziness or to prevent a fall. Immediately following the completion of the walking,

participants were seated, and heart rates and blood pressure were measured. For monitoring purposes, heart pulse (1 minute), blood pressure (in mmHg), and respiration rates were recorded before and after each training session.

Ball exercises.—Large gymnastic balls made of thick vinyl were used for the therapeutic exercises. These balls function as important aids in achieving normal movement and equilibrium. Two ball sizes were chosen according to the height of the participants: a green 65-cm ball (for those of 1.60–1.70 m height) and a red 75-cm ball (for taller individuals, from 1.70–1.80 m in height). As recommended by Mayer (12), a series of 40 ball exercises was selected out of 270. Three physical therapists with 3–4 years' experience participated on a "one-to-one" basis (i.e., individual exercise). The ball exercises were all performed individually in standing, sitting, and lying positions on 5-mm-thick shock-absorbing mats. Typical exercises included supine trunk curl, prone trunk extension, and side-lying lateral flexion. The ball exercises were designed to improve control of postural alignment, balance, and also to strengthen specific muscle groups. Ball exercises involving whole-body activities help improve midline orientation while forcing the body to make rapid compensatory movements. The ball exercises integrate body strengthening with the mobility and coordination needed for everyday functional activities. The ball distributes body weight over relatively large, yet dynamic, support and lowers the height of the body, allowing equilibrium reactions and difficult movement patterns to be elicited at a relatively safe distance from the floor. Ball exercises condition physiological "stimulus-response interactions" of the neuromuscular system. The ball exercises were given twice a week for 23 weeks, starting on week 2 and concluding 1 week earlier than the treadmill-walking program. Each session of ball exercises lasted 20–30 minutes, as tolerated by individual participants.

Data Analysis

All data were analyzed with SPSS 7.2 for Windows 2000 (SPSS, Inc., Chicago, IL). Means and standard deviations were calculated for all variables. Dependent *t* tests were run to compare the 2 training programs to the 5 different balance items. The 5 different tests were combined to determine overall balance by using analysis of variance. The correlation coefficient used for the 5 tests was Spearman rank. The critical value for statistical significance was assumed at an alpha level $<.05$.

RESULTS

The results for the pre- and post-training are shown in Tables 1 and 2. The effect of walking and ball exercise on each of the balance tests is demonstrated in Table 2. The lack of improvement in balance control was noted in 3 out of 5 tests. The Spearman rank correlation coefficient for each of the 5 tests before and after the training is demonstrated in Table 1. The high acceptability of the 5 clinical tests, administered at 3 different time periods to the adults with ID, was determined by the participant's ability to

Table 1. Spearman Rank Correlation Coefficient of the 5 Clinical Tests: Pre-Training Versus Post-Training ($N = 15$). The Upper Figures Represent Pre-Training Values and the Lower Figures Represent Post-Training Values

	TUG	FT	FR	OLS	StS
TUG		0.66* 0.67	0.57 0.59	0.31 0.33	0.36 0.40
FT	0.66* 0.67		0.47 0.49	0.46 0.48	0.31 0.35
FR	0.57 0.59	0.47 0.49		0.78* 0.79	0.28 0.33
OLS	0.31 0.33	0.46 0.48	0.78 0.79		0.25 0.32
StS	0.36 0.40	0.31 0.35	0.28 0.33	0.25 0.32	

Note: TUG = timed up-and-go test; FT = full turn test; FR = forward reach test; OLS = one-legged standing test; StS = sit-to-stand test.

*Positive correlation between the 2 tests. (TUG and FT show positive correlation; FR and OLS are also positively correlated).

complete the test as evaluated by the tester. The value of each test is indicated by the progressive increase in total scores as participants continue in the program. Fifteen of 17 participants completed the training protocol. Two individuals dropped out: one was a 59-year-old woman who was stopped after pretesting because she did not want to be available for the ball exercises, and one man stopped at the investigator's request in week 4 as a result of unexpected low back pain during the ball exercises. The average training attendance rate of the participants who completed the program was 85% over the 27 weeks. The rate of absenteeism is demonstrated in Table 3. In total, participants ranged from 9 sessions (12%) to 20 sessions (30%) out of a possible 72 sessions of the treadmill program and from 4 sessions (9%) to 9 sessions (18%) out of a possible 48 sessions of ball exercises. No atypical pulmonary, cardiovascular, or musculoskeletal complications were noted.

Clinical Balance Data

In general, the ICC coefficients between the scores varied from mild to good, with a range from $r = .25$ to $.78$, as was also found in a previous publication of Carmeli and colleagues (26). The correlation analysis of the pretraining program indicated the following: TUG test determinations showed a high positive correlation ($r = .66$) with measurements of the FT test. A strong positive correlation was also found between the FR and OLS tests ($r = .78$). The StS measurements showed only moderate correlation with the TUG ($r = .36$), FR ($r = .28$), and OLS ($r = .25$) tests. The correlation analysis of the post-training program compared with pretraining (Table 1) demonstrates a higher correlation coefficient between the 5 tests as well as a particularly elevated correlation between StS and the other four tests. The performance results for each clinical test are shown in Table 2. The training program positively influenced the results for all 5 tests. Post-training measurements were significantly better than those of pretraining in FR and StS tests. The posttraining improvements ranged from 9.5% (StS) to 18% (FR-Max)—post-training compared with

Table 2. Summary of Pre-Training and Post-Training Values for the Various Tests ($n = 15$)

	TUG (sec)	FT (sec/steps)		FR (cm)			OLS (%)	StS (repeats)
		Left	Right	Min	Max	Mean		
Pre-training	24.2 $\pm$ 2.4	3.7/9	3.8/10	16/35 $\pm$ 2.2	26.51 $\pm$ 2.5	20.79 $\pm$ 3.1	57 $n = 9$	6.7 $\pm$ 0.3
Post-training	21.5 $\pm$ 3.6	3.2/8	3.3/9	19.75 $\pm$ 3.2	30.12 $\pm$ 4.2	24.60 $\pm$ 3.3	65 $n = 11$	7.4 $\pm$ 0.4
% Change*	-11.1	-13.5	-13.1	+20	+13.6	+18	+8	+9.5
$p >$	NS	NS			.05		NS	.05
Control Group A [†] ($n = 12$)	23.9 $\pm$ 2	3.7/9	3.7/9	16.22 $\pm$ 3	25.9 $\pm$ 4	21.1 $\pm$ 3	58 $n = 9$	6.5 $\pm$ 0.4
Control group B [†] ($n = 20$)	18.1 $\pm$ 3.5	3.1/8	3.1/8	23.37 $\pm$ 3.4	NA	29.6 $\pm$ 3.8	95	9.5 $\pm$ 0.4
Difference (%) [‡]	+11/-16	+15	-3	-19/+6	-14/NA	-15/+20	-11/+46	-13/+28
$p >$	.05/.05	NS			.05/.05		.05	.05

Note: TUG = timed up-and-go test; FT = full turn test; FR = forward reach test; OLS = one-legged standing test; StS = sit-to-stand test; p = probability; NS = not significant; N/A = not applicable.

*% Change comparing posttraining with pretraining values.

[†]The control groups A and B were tested twice; however, their scores remain constant.

[‡]% Difference control group A and B compared with posttrained ID group.

pretraining values. Table 2 demonstrates the differences in test scores between pre- and post-training and the control group.

DISCUSSION

Preventing or delaying the onset of functional decline is a crucial important goal, because more individuals with ID are living well into their sixth and seventh decades. Older individuals with ID are functioning dangerously when performing normal daily activities such as climbing stairs, getting out of a chair, or lifting objects. Any further decline could lead them to more sedentary lifestyle and shift them from independent individuals to those of disabled status, in which case assistance is needed and the risk of falling is increased. Too often clinicians take it for granted that the treadmill and ball exercise regime would or should seem important and useful in its own right in terms of promoting general fitness (27) or even improving balance. The results of our study do not appear to show clinically significant improvement of balance despite 6 months of intervention.

Evidence about the effect of walking training on aerobic capacity, on general health status, on reaction, and on movement time has been previously reported (27). The question of whether walking and ball exercises can effect balance performance as well as inquiry into which balance test would be more affected by 6 months of training have never before been investigated. The question of whether walking and ball exercise could positively effect balance as much as specific functional activities do is a valid concern. Thus, regardless of the lack of evidence-based practice, clinicians often train their clients on a treadmill and ball to improve those systems that are apparently directly and indirectly involved in maintaining balance.

Measurements of the physical and clinical capabilities of adults with ID are both challenging and informative for the therapist (28). Such methods can provide objective, quantifiable, and variable indications of physical performance. Moreover, the combination of several different tests reduces possible discrepancies between what the participant can actually do and how the therapist interprets the results. The use of several different tests improves the overall

validity of assessing physical capabilities, as was recommended by Rikli and Jones (29).

The relative lack of mobility and the high prevalence of falls in adults with ID requires that physical and functional assessment tests include a reliable, comprehensive, and easily administered test for balance. Several measures have been developed in order to assess balance and static and dynamic postural control (8,30). Using just 1 or 2 clinical tests to assess balance may provide misleading indications of actual capabilities.

In this study we used 5 tests that are inexpensive, precise, repeatable, and safe to perform. Each test measures different components of balance mechanisms and control. Thus, the combination of the 5 tests provides an excellent means to determine overall balance characteristics and functional capabilities of individual participants. It is important to undertake both static and dynamic assessments in order to determine the following: ability to remain upright with minimal support (OLS), anticipation and preparation for multifactorial tasks (TUG), impaired coordination of postural adjustments of lower extremities (FT), weak muscles of lower limbs (StS), and postural sway (FR) (31). The question that should be addressed is "What can be learned from a combination of balance assessments?" Balance assessment using 5 different, but specific, tests provides a more accurate determination of balance control (28). For example, a participant who gets a "good" score on the TUG test may not necessarily perform at an identical level in the StS test. Lower scores on this test may indicate specific weakness of the lower limbs that requires lower-leg muscle strengthening.

The effects of walking on balance performance and on improving leg power in older adults have been reported (32-34). In the present study, following 24 weeks of treadmill walking and a program of ball exercises, results of all of the 5 balance tests showed little or no improvement. Specifically, only 2 (FR and StS) were significantly improved ($p > .05$). Gustafson and colleagues (35) reported that walking training and balance training could improve one-legged standing and postural sway.

The reason or reasons for the disappointing finding in this study remain unclear. On the one hand, this negative outcome could indicate that the sample size provided

Table 3. Absenteeism Rate ($n = 15$)

Participant No.	Ball Training ($N =$ total possible sessions = 48) Absenteeism (%)	Walking Training ($N =$ total possible sessions = 72) Absenteeism (%)
1	9	14
2	9	17
3	10	18
4	15	12
5	10	19
6	18	12
7	10	12
8	16	20
9	13	13
10	9	17
11	12	14
12	9	12
13	10	12
14	9	13
15	14	14
Range (%)	9–18	12–20
Mean $\pm$ SD	11.5 $\pm$ 3	14.6 $\pm$ 6

Note: SD = Standard deviation.

insufficient power to detect a treatment effect, and even when significant differences were obtained (i.e., on the FR and StS tests), the magnitude of the differences were, unfortunately, clinically insignificant. On the other hand, one can claim that the lack of improvement could indicate that the treatment was not intensive enough. We believe that if after 6 months of treatment the results were not positive, it would seem that this approach was not effective. A surprising result in our study was that only 2 of the 5 balance tests were significant. The possible explanation would imply that there exists a difference among adults in terms of their ability to acquire motor skills (36), a difference that is related to age, gender, fitness, and cognitive level. The mechanism by which to understand this theory is future investigative studies. It is important to point out that the post-training values of the ID study group were still inferior to the baseline values of the control group B (non-ID), but the values were superior to those of control group A.

Two major limitations of this study need to be addressed. First, the small sample size of the study does not allow for generalization of the outcomes. Future studies should utilize at least 31 participants in order to obtain a more statistically significant result. Second, the absenteeism rate of 2 participants might influence the outcome interpretations.

Conclusions

In summary, the results of this study showed that use of a combination of 5 different clinical assessment tests to detect balance and mobility impairments can provide a highly accurate overall assessment of balance capabilities in adults with intellectual disabilities. It is possible that not all of the 5 tests are necessary to reach accurate conclusions, based on the correlation found between specific tests. The strong correlation between the TUG and FT tests and between the FR and OLS tests may indicate that there is an option to eliminate one of each pair of tests during clinical evaluation for balance.

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Can physical training have an effect on well-being in adults with mild intellectual disability?

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Abstract

The aim of this study was to investigate the effect of physical training on balance, strength, and general well-being in adult people with intellectual disability (ID). This study evaluated how physical training can effect physical and psychological change among 'older' adults with mild ID. Participants consisted of non-randomly selected groups with ID ($n = 22$), between 54 and 66 years of age. Clinical balance functional tests were measured by a modified Timed Get-up and Go test and Functional Reach test. Knee muscles strength were measured on a Biodex dynamometer. The self-concept of well-being was measured by direct interview with a questionnaire consisting of 37 structural statements. Physical training program was conducted three times a week for six consecutive months. Multiple regression analyses suggested positive relations between balance, muscle strength, well-being and physical training between the experimental and control group. This positive relation can support the role and importance of physical training to improve locomotor performance and perception of well-being among 'older' adults with ID.

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Keywords: Intellectual disability; Aging; Well-being; Physical training; Muscle; Balance

1. Introduction

Aging people with a lifelong intellectual disability (ID) are a new demographic trend requires from policy makers and welfare system to respond to their needs and expectations (Turner and Moss, 1996), each country in the context of its tradition, structure and cultural values (WHO, 2000; Carmeli and Coleman, 2001).

It is estimated that the incidence of ID people in Israel is about 3.5% of the general population and 6% of ID people are adults aged 55 years or more (Merrick and Kandel, 2003). Increased life expectancy in the ID population enhances the incidence of aging disease and functional debility. Moreover, individuals with ID show several

characteristics of premature aging, resulting in greater tendency towards deconditioning and morbidity (Ashman and Suttie, 1996).

Much research on older adults without ID has been performed to identify extrinsic and intrinsic factors related to muscle weakness falls (Jerome et al., 2000). However, little attention has been paid to the balance and strength assessment and training of adults with ID (Fernhall, 1993; Carmeli et al., 2002, 2003).

Positive effects of physical activity on mental health and psychological well-being (including various outcome measures such as mood, life satisfaction and self efficacy or confidence) has been reported for adults aged 60 years and older (Boutcher, 2000; Callaghan, 2004; Atlantis et al., 2004), but very little attention has been paid to the well-being of adults with intellectual disability. Maladaptive behavior and psychological changes related to aging in

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people with ID have been reported previously (Matson et al., 2003; Urv et al., 2003) and a meta-analytic review indicated that individuals with ID often put themselves down due to cultural isolation, social discrimination and general neglect (Deci et al., 1999). This negative self-concept in individuals with ID has been associated with depression, anxiety, lack of motivation, or anger, just as in persons without ID (Dagnan and Sandhu, 1999). A few studies on the effect of physical training on general well-being and self-image in people with ID have been reported, mostly with children or adolescents (Dykens et al., 1998; Ninot et al., 2000; Maiano et al., 2001) and only a few involving adults (Gabler-Halle et al., 1993; McAuley et al., 2000).

It seems highly accurate to examine the balance, strength and well-being of older adults with ID and to examine the effect of training program on these variables. Hypothesis was raised whether a physical training program with extra emphasized on balance and muscle strength can be considered as a valuable way to enhance locomotor performance and well-being among older adults with ID.

2. Material and methods

A repeated-measures experimental design with two intervention groups was chosen. The experimental intervention of Group A focused specifically on an improvement of the balance and muscle strength, and the experimental intervention of Group B received general exercises. The training program was performed 3 days a week during six consecutive months.

The study was based on a single-blind design, involved hiding the identity of group assignments from those who provided treatment, those who measured outcome variables and from those who analysed the data.

2.1. Participants

Twenty-two participants, ranging from 54 to 66 years old were derived from a non-randomly selected sample of 112 permanent residents from a foster home located in Israel. They all had mild ID requiring minimal supervision for daily living activities (ADLs). The selected participants, excluded Down syndrome, unable to understand or to answering the 'well-being' questionnaire, minimal loss of visual acuity, requiring at least moderate assistance in ADLs, lived at least 5 years in the foster home.

We equally divided them into two groups qualitatively, then quantitatively. Qualitatively, we matched the two groups in terms of four inclusion criteria: gender, age, duration of institutionalized, and IQ level (using Wechsler Abbreviated Scale of Intelligence) (Hays et al., 2002). Quantitatively, a multi regression analyses showed no difference between the two groups. Thus, we were able to consider the two groups as equal.

Group A ($n = 10$), balance and muscle strength exercise training included seven women and three men, (mean age 60.9 ± 3.3 years). Group B ($n = 12$), general exercise included eight women and four men (mean age 61.5 ± 4.1 years). All had mild ID requiring none to minimal supervision for daily activities.

The study was performed in accordance with the Helsinki declaration approved by the National Institute of Child Health and Human Development, Office of the Medical Director, Division for Mental Retardation, Ministry of Social Affairs and by the ethics committee of the foster home. Oral consent obtained from each participant, as well as a written consent was given to their caretakers.

2.2. Experimental procedures

In this longitudinal study all participants were evaluated prior to and following the 6 months study period. Two sets of timetable were defined: T1 initial evaluation and T2 at the end of a training program. All testing procedures and instruments were identical.

- 1) Timed Up and Go Test (TUGT) was used to measure the dynamic balance and gait speed. The test was modified as previously described (Carmeli et al., 2002), in which the subjects was asked to rise from an armchair, walk 9 m, and return to the chair (total walking distance if 18 m).
- 2) Functional Reach Test (FRT) (Duncan et al., 1990). The test requires that the individual reach forward in a 'feet in place' position while keeping the legs slightly apart. The participant reaches forward with hands and arms extended, parallel to a yardstick hanging on the wall. The base of metacarpal V (the point on the little finger side of the hand, just above the wrist) was used as a reference landmark, and the distance moved in the stretch was measured. The best score of three trials was recorded.
- 3) Knee flexion and extension strength were measured, in a sitting position, from both sides using a medical isokinetic system (Biodex, Medical Systems, Shirley, NY, USA). After warm-up, subjects performed three maximal repetitions of knee flexion extension at speeds of $60^\circ/\text{s}$.
- 4) Well-being questionnaire—To measure self-concept of well-being, we modified the Harter's self-perception profile (Aasland and Diseth, 1999) with performed inter judgmental validation. Five known specialists in the field of gerontology, intellectual disability and psychology determined a content validity, which composed of 37 statements including two domains of self-concept of well-being: social competence (17 questions) and physical appearance (20 questions). Good to excellent agreement (k statistic), from 67 to 88%, was observed between the raters.

The interview format was carried out in an individual manner in standardized conditions (face-to-face, time and

location). Their perception of general self-concept was graded on a scale of assurance. First, the participants were required to choose the statement that most reflected themselves (i.e. high or low assurance, 'yes' or 'no'), secondly to indicate the degree to which the statement was true or not true (in case of 'yes': 'sort of true', 'really true' or in case of 'no': 'fairly not', 'absolutely not').

2.3. Balance-training program

Two physical therapists conducted the balance exercise program, alternately. The balance-training program was carried out for 40–45 min. The program included warming-up movements followed by dynamic balance exercise (i.e. toe-to-heel walk, tandem standing, side walking, reverse walking, with eyes opened versus closed). Balls, balloons, bands, sticks, and scarves were used in conjunction with the dynamic exercises. In addition, general dynamic activities such as dancing, rolling a ball, pushing, pulling, lifting, catching and throwing were practice in each session. In each session the participants advised to 'listen' to their body, to focus on their stability, and to pay extra attention to expect and unexpected stimuli.

2.4. Muscle strengthening program

The prescribed exercise program was according to the guidelines set by the American College of Sport Medicine, and as recommended by Evans (1999). In general, after determining the one repetition maximum (1RM), one to two sets of eight and 10 repetitions can accomplish muscle strengthening. As soon as an individualized 70% of 1RM has been established, weight increased 10% each week. One RM for abdominals and erector spine muscles was not performed to avoid overload and chances of causing back pain. Seven basic exercises were used each session: knee extension, knee flexion, ankle plantar flexion, hip extension, hip abduction, trunk flexion (abdominals), and trunk extension (erector spine). The participants rested 2–4 min between sets, and the program took 5–10 min to complete for each muscle group. Strength-training sessions lasted approximately 45 min and were separated by a least 1-day of rest. Thus, the participants could do their best three times per week. Prior to each exercise session, subjects performed a warming up movements. The timing of lifting or holding the weights was 3–4 s lift and a 4–5 s lowering. Participant inhaled before a lift, exhaled during the lift, and inhaled as the weight was lowered. All sessions were supervised, and no more than two participants at a time were assigned to one therapist.

2.5. General exercise program

The exercise program was according to the guidelines set by the American College of Sport Medicine (American College of Sports Medicine, 2000). The general exercise program was performed 3 days a week during six

consecutive months. A physical therapist and physical education teacher conducted the exercise, alternately, and was carried out for 40–45 min. The program included warming-up movements followed by large body movements in sitting, standing (trunk bending, pelvic rotation, arm's movements) and walking for general mobility, stability and flexibility. Free hand-weights, floor mats (i.e. prone and supine position, rolling, 'dog standing') and chairs rails-free, were the only tools used in the group.

2.6. Statistical analysis

Statistical analyses were performed using a statistical package (SPSS 10). Standard procedures were used for all variables to calculate mean $\pm$ S.D. and correlation coefficient (Pearson r). To evaluate the results of the post-training programs, multivariate analysis of variance (MANOVA) with repeated measurement on the time of measurement (T1 and T2) were used.

The inter testers reliability for the 'well-being' questionnaire to measure percentage of agreement, was assessed by kappa statistics (k).

Within-group differences from the baseline to post-training measurements of absence rate were also assessed using Student's t -test (2-tailed) for repeated measures. Statistical significance was accepted at an alpha level $P < 0.05$.

3. Results

As was expected, both groups showed improvements in self-concept of well-being between baseline (T1) and post test (T2), but only improvement in balance (TUGT; FTR) and knee muscle strength (average values of three repetitions) abilities demonstrated in group A comparing group B (Table 1). This significant change justifies promoting a specific balance and muscle strength exercise training rather than general exercise training in order to improve both well-being, balance and muscle strength.

3.1. Well-being

The two groups were compared according to well-being scores at the beginning (T1) and at the conclusion of the study (T2). The change in well-being due to exercise in older adults with ID was found significant. The mean points of the total objective and subjective statements of the well-being of the groups throughout the training program (T1, T2) are demonstrated in Table 1.

3.2. Muscle strength

After 6 months of strengthening program the angular velocity of 60°/s, the peak torque and peak torque % body weight and knee flexion and extension in Group A were

Table 1
Summary of pre training (T1) and post training (T2) values for the various tests

Variable	Group A (n = 10)			Group B (n = 12)		
	T1	T2	P value	T1	T2	P value
Age (years)		60.9 ± 3.3			61.5 ± 4.1	
BMI ^a						
Males		22.9 ± 5			23.1 ± 4	
Females		23.6 ± 6			23.0 ± 5	
Modified Timed Up and Go Test (s)	26.4 ± 3	21.2 ± 4	0.05	25.9 ± 2	23.4 ± 4	NS
Functional Reach Test (cm)	22.9	24.8	0.05	23.3	24.0	NS
Muscle strength ^b						
Knee extension: dynamic torque (Nm)	42.7 ± 2	47.5 ± 2	0.05	43.1 ± 1	43.3 ± 2	NS
Dynamic torque % BW (Nm/kg)	50.5 ± 2	57.3 ± 4	0.05	51.9 ± 2	52.7 ± 1	NS
Knee flexion: dynamic torque (Nm)	28.7 ± 2	37.5 ± 4	0.05	29.1 ± 3	30.5 ± 2	NS
Dynamic torque % BW (Nm/kg)	13.5 ± 3	18.7 ± 5	0.05	14.3 ± 4	15.3 ± 4	NS
Well-being (points)	68 ± 7	83 ± 9	0.05	67 ± 8	85 ± 8	0.05

^a BMI—Body mass index (body weight/height²) units are kg/m².

^b Data are the average values of three repetitions.

significantly higher than the pre training values and Group B.

3.3. Balance

Following the 6 months of the training program, the values of the TUGT and FRT in Group A were significantly higher than the pre training values and Group B.

4. Discussion

In our study we found that the implementation of a physical training program for individuals with ID could enhance their perception of well-being and functional ability. Thus, it seems like every physical activity can improve the self-concept of well-being however, only specific balance and strength training program can also improve physical performance. As such, we could partially validate our hypothesis that foresaw a positive relation between perception of well-being and physical training. This enhanced perception of well-being may also contribute to more positive self-concept. This perception is in keeping with the results obtained by previous studies done on young individuals with ID (Compton et al., 1989; Gabler-Halle et al., 1993; Dykens et al., 1998). Three factors may explain the mechanism of why and how physical exercises can affect the well-being of older adults with ID.

- 1) In the present study the general life-style of the participants exposed them to none or little familiarity with physical activity. Previous studies indicated that structural physical training helped to increase well-being and general mood by reducing social stress, psychological fatigue, anxiety and feelings of depression (Stear, 2003), while positive moods and self-confidence were

rated higher following 12 consecutive days of exercise (Steptoe et al., 1998).

- 2) The extent of how physical training related to changes in self-perception and body image in older adults was discussed by McAuley et al. (2000), who found that an 'attractive body', better fitness, greater physical condition and physical worth due to exercise improved self esteem perception and self-efficacy.
- 3) Findings of the present study suggested that physical training improved psychological perception. According to recent studies physical activity appears to affect brain function as a result of its influence on important neurotransmitter chemicals in the central nervous system (i.e. encephalin, dopamine, serotonin). Such molecules are responsible in regulating mood, control additional resources and sense of relief necessary for social, mental, cognitive and psychological performance (Brosse et al., 2002). In addition, exercise affected cerebral blood flow and increased oxygen level and brain cell metabolism in particular areas of the brain such as the limbic system and the frontal lobe (Morgan, 1985).

Muscle strength and balance is necessary for many mobility tasks such as household tasks, walking and climbing. The results of this study suggest that a person with mild ID will benefit more (in term of well-being and functional performance) from balance and muscle strength program rather than a general activity program.

Preventing the onset of functional decline is a major aim for health care givers in foster homes. Any functional debility or psychological stress or mal function could lead ID individuals to more sedentary life style and increased the burden of the supporting environment.

Our study is novel in that significant functional changes were seen following balance and strengthening training and not following general training, which may contribute to

understand the adaptability of motor learning in this unique population.

The retention of the observed outcomes has yet to be investigated. It is not known whether the exercise program effects on balance, muscle and well-being demonstrated in this study would be seen several months after the program was terminated. A permanent or continuous change in locomotion and well-being requires the ability to learn. The learning capacity and the adjusted ability in older adults with ID are limited, yet it is fair to believe that on-going exercise program may slow down some psychological and physical changes that lead to poor well-being perception, and functional performance and cause some social and psychological disorders (Tompowski and Ellis, 1984).

In summary, the results in this study are limited to the unique participants included in this study. The results of this study demonstrated that, with an exercise program over six consecutive months, older adults with ID were able to show a better perception of well-being, and a specific balance and muscle strength training can also improve locomotor performance. Moreover, we believe that lifestyle incorporating physical activity could better preserved a good physical function in the later years of life particularly with such a unique population that stays in great risks for morbidity and debility. The mechanisms involve in such change is unclear and the retention, once the program is ceased, remains to be investigated.

Two major limitations of this study need to be addressed. First, as with validation studies of other well-being questionnaires, we were unable to test against a 'gold standard' for well-being capacity. Although participants may have been able to complete or answer 'conditions' in this study setting, they may be less motivated to perform or answer similar 'conditions' at their regular environment. The adjusted 'well-being' questionnaire, like all other self-reported questionnaires, cannot differentiate unmotivated from incapable participants, let alone when the participants involved are individuals with ID. Second, the sample size does not allow for generalization of the outcomes, and to reproduce the same results. Future studies should utilize at least 35 participants in order to obtain a more statistically significant result.

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Original research article

Physical exercises can reduce anxiety and improve quality of life among adults with intellectual disability

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Abstract

Background: Anxiety is common among people with a disability in general. Several studies have indicated that anxiety states may lead to hypokinesia and a 'sedentary' lifestyle. Anxiety reduction may improve the quality of life of people who suffer from intellectual disability (ID), as well as reducing health and social care expenses. **Objective:** To determine the effectiveness of physical activity interventions on reducing anxiety and improving quality of life (QoL) of persons who suffer from mild ID and anxiety. **Methods:** The sample consisted of 24 participants with the dual diagnosis of mild ID and anxiety. Participants were randomly assigned to one of three groups: aerobic training (n=8); leisure activities (n=8); and control (n=8). The aerobic programme (experimental group) consisted of three ergometric bicycle or treadmill sessions per week over a 6-month period (26 weeks). The leisure programme consisted of a varied range of activities (i.e. games and general exercises). The psychometrically sound, Hamilton Anxiety Scale (HAM-A), was used to quantify the severity of anxiety symptomatology and QoL. **Results:** Of the 24 participants, 19 participants completed the programme (experimental group n=7, leisure group n=5, control group n=7). However, only 16 participants agreed to complete the HAM-A. After 6 months only the experimental and leisure groups showed significant improvements ($p<0.05$) in the HAM-A. **Conclusions:** The implementation of an aerobic physical training programme or leisure structural activity programme for individuals with ID significantly and clinically reduced their level of anxiety. These authors could validate their hypothesis that foresaw a positive relationship between a psychiatric disorder, such as anxiety, and physical activity. **Keywords:** intellectual disability; physical exercise; quality of life; anxiety

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Introduction

There were dramatic increases in the life expectancy of individuals with intellectual disability (ID) during the 20th century, due chiefly to medical and social advances. With this new demographic trend in mind, policymakers, welfare systems and service providers must identify key features of health practices that would support persons with ID longevity and healthy aging and, consequently, decrease the prevalence of psychological conditions, such as mood disorders¹⁻³. Symptoms for mood disorders are characterised by inadequate affective manifestations, such as depression and anxiety. These disorders promote alterations that affect a person's quality of life (QoL), particularly by restricting their social life and gradually reducing their independence⁴. The concept of 'QoL' is a subjective concept representing the quest for happiness and pleasure in all aspects of life. More specifically, QoL is defined as a perceived

global satisfaction and satisfaction within a number of key domains with a special emphasis on well-being (e.g. limitations in social activities because of physical or emotional problems, and limitations in normal role activities because of physical health problems). A few investigators⁵⁻⁶ claim that the aims of health promotion programmes for people with disabilities are not only to reduce secondary conditions (e.g. obesity, hypertension, pressure sores) and to maintain functional independence, but also to provide an opportunity for leisure and enjoyment, and to enhance overall QoL by reducing environmental barriers to good health. In addition, Rimmer⁶ implied that treating the physical ailments as the primary focus will also have an impact on the QoL of individuals with ID. QoL may be reduced as a result of certain mental disorders such as anxiety. Anxiety is a disabling condition which is associated with the progression of disability⁷, functional decline, and cognitive and psychological



impairment. Unfortunately, anxiety is common among persons with physical disability and ID. The prevalence of ID in the general population is about 3.5%⁸. Within this population, 12-14% have an anxiety disorder that has been present for at least 6 months. Dual diagnosis is a conceptualisation of co-morbidity in adults with an ID. The term 'dual diagnosis' specifically refers to co-existing ID and mental disorders⁹. This population is growing in numbers and will continue to make significant demands upon human-, health- and disability services. The prevalence of dual diagnosis varies according to definitions, diagnostic criteria, age, and the location of the population studied. There are a number of key issues related to why adults with an ID are more likely to experience an episode of mental illness during their lifetime. For instance, a number of syndromes of genetic origin result in ID associated with mental disorders, and brain trauma or insult can also result in mental health problems.

Several methodologies have shown associations between physical exercise and improvement in mental health symptoms in various populations¹⁰. Observational and interventional studies have suggested that regular physical exercise may be associated with reduced symptoms of anxiety in non-clinical populations. In addition, exercise training has been shown to decrease feelings of depression and anxiety among the elderly¹¹. Moreover, the available evidence suggests that physical exercise is associated with improved general well-being, health, quality of life, disease prevention, and prolonged life in older adults with mild intellectual disability. However, to date, no previous study has demonstrated whether or not exercise yields similar benefits in individuals with ID. Although the majority of exercise studies have focused on changes in negative effects, such as anxiety and depression, some studies have shown that exercise can also increase positive feelings¹². Furthermore, while current studies demonstrate improvement in the physical and social functioning of older adults (60 years and older) and their emotional well-being following the implementation of an exercise training programme¹³, little attention has been

paid to the perceived well-being of adults with ID. Emotional well-being is defined as a greater amount of positive effects than negative effects, along with favourable thoughts, such as satisfaction with life, increased positive emotions like energy and vigour, greater self-confidence, self-esteem and improved cognitive function, which all serve to bolster well-being¹⁴. For instance, depressed and anxious individuals view their appearance more negatively than non-depressed and non-anxious individuals, despite the lack of differences between these groups in actual body shape or size. This enhanced perception of well-being may also contribute to a more positive well-being. This perception is in line with the results obtained from previous studies on young individuals with ID¹⁵⁻¹⁷. Heller et al.¹⁸ have addressed the issues of physical and psychological well-being in a population of aging individuals with Down syndrome. There were 53 adult participants with Down syndrome aged 30 years and older. The training group participated in a 12-week, three days per week, exercise and health education programme. Outcome measures included attitudes towards exercise (cognitive-emotional barriers, outcomes expectations, and performance self-efficacy) and psychosocial well-being (community integration, depression, and life satisfaction). Compared to controls, the training group showed significant changes in attitudes towards exercise, including increased exercise self-efficacy, more positive expected outcomes, fewer cognitive-emotional barriers, improved life satisfaction, and marginally lower depression.

Few investigators suggest that people with ID experience at least as much or more stress than the general population¹⁹, yet they have fewer resources (internal and external) to manage their stress²⁰. Potential stressors arise from the greater risk people with ID face of being marginalised within society²¹, which manifests itself in prejudice and discrimination.

Therefore individuals with ID face not only the personal challenges and demands of their disability, but also restricting environmental factors that persons without a disability do not have to struggle with.



Consequently, it is crucial to establish whether a simple intervention, such as exercise training, could reduce the anxiety level in persons with ID and improve their QoL.

The purpose of this study was to investigate whether, and to what extent, a reduction of anxiety and improvement in quality of life can be achieved by means of physical activity.

Methods

The study procedures were followed in accordance to local institutional guidelines. Informed oral consent was obtained from all study participants, as well as a written consent from the participants' legal guardians.

Sample

Twenty-four volunteers with a dual diagnosis of mild ID and anxiety were recruited for the study from a residential care centre in Israel with 228 permanent residents. Patients ranged in age from 45 to 55 years of age (mean age 51.2 years). Exclusion criteria for participation included: (1) the use of antidepressant medications, (2) the use of medications that would preclude random assignment to exercise training (e.g. quinidine, metoprolol), and (3) medical contra-indications to exercise (i.e. significant orthopaedic problems or cardiopulmonary disease that would prevent regular aerobic exercise) were excluded.

Interventions

The sample was divided into 3 treatment groups: aerobic training (n=8, 5 females and 3 males), leisure activities (n=8, 6 females, 2 males), and control (n=8, 4 females, 4 males). The aerobic programme consisted of three ergometric bicycle or treadmill sessions per week over a 6 months period (26 weeks). The leisure programme consisted of a varied range of activities, such as games and exercises. Finally, the control group participants were introduced to a new set of vocational activities, such as packing small candles. The control group did not receive any physical intervention. All participants required none to minimal supervision in activities of daily living.

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Measures and procedures

The Hamilton Anxiety Scale²² is a rating scale developed to quantify the severity of anxiety symptoms and to determine treatment outcomes. The HAM-A is a psychometrically valid measure for collecting data on the levels of QoL from persons with ID who attend residential care centres. It consists of 14 items, each defined by a series of symptoms. Each item is rated on a 5-point scale, ranging from 0 (not present) to 4 (severe). In an effort to adjust the HAM-A to a participant's unique intellectual ability, the following items were excluded: the intellectual symptoms, autonomic symptoms, visceral complaints (i.e. respiratory, heart, GI, etc.), and insomnia symptoms. The items used for this study were: 1) Anxious mood: Worries and anticipates worst; 2) Tension: Startles, cries easily, restless, and trembling; 3) Fears: Fear of the dark, fear of strangers, fear of being alone, and fear of animals; 4) Depression: Decreased interest in activities; 5) Somatic complaints of muscles: muscle aches or pains, bruxism; and 6) Somatic complaints of sensation: tinnitus, and blurred vision.

All participants were assessed at the beginning (T1) and following the 6-months study period (T2). All testing procedures and instruments were identical at T1, and T2. By operational definition, participants who received a HAM-A score within the range of 6-8 were considered to be mildly clinically anxious, whereas participants who obtained a HAM-A score of 9 or more were considered to be moderately to severely anxious. To evaluate interrater reliability, 3 randomly selected interviews were independently rated by two clinicians. The intraclass correlation for the raters was 0.88 and 0.82. The interview format was carried out individually under standardised conditions (face-to-face, time, and location). The interviewers were blind to the condition experienced by each participant.

Aerobic training

The prescribed exercise programme conformed to the guidelines set by the American College of Sport Medicine



(ACSM)²³. The training programme was performed three days a week over 10 consecutive months. Participants attended 3 supervised exercise sessions per week for 26 consecutive weeks. Participants were assigned individual training regimens. Training intensity was defined in terms of percentage of heart rate reserve (the difference between a person's measured or predicted maximum heart rate and resting heart rate). The training percentage of heart rate reserve ranged from 50% to 70% (low-moderate training intensity)²⁴. Heart rate reserve was calculated from the maximum heart rate achieved during a treadmill exercise tolerance test. Each aerobic session began with a 10-minute warm-up, followed by 20 minutes of continuous walking or jogging at an intensity that would maintain heart rate within the assigned training range. The exercise session concluded with 5 minutes of cool down exercises. Heart rates were monitored via radial pulses and were recorded. A physical therapist and a physical education teacher, who were familiar with the participants, conducted the aerobic training, alternately. The training programme session was carried out for 20-40 minutes each. The experimental group trained as a group and not on an individual basis.

Leisure programme

The leisure programme consisted of warming-up movements followed by large body movements in sitting and standing positions which focused on stability, flexibility, and dynamic balance (i.e. toe-to-heel walk). Balls, balloons, bands, sticks, bean bags and scarves were used for general activities, such as pushing, pulling, lifting, throwing, squeezing and pressing. As in the experimental group, the participants in the leisure group did their activities for 20-40 minutes.

Data analysis

All data were checked for normal distribution, i.e. 'normal' refers to a specific type of bell-shaped/symmetrical distribution where most of the scores fall in the middle of the scale and progressively fewer fall at the extremes. Thus the *t*-test was used as a non-parametric test of

significance. Statistical analyses were performed using a statistical package (SPSS 11 for Windows 2000). Chi square tests for cross-tabulation tables and the Student's *t*-test were used to compare the prevalence of health and lifestyle factors in the three groups at initial assessment. Standard procedures were used for all variables to calculate mean $\pm$ SD, and 95% confidence intervals by age and sex calculated for each questionnaire test. Repeated measurements with the questionnaires, made within the same data collection session, showed high intraclass classifications (ICCs, 0.95) for the questionnaire. The generalisability coefficients represent the relative generalisability of a measurement to the total range of possible scores for that measurement, with results ranging from 0.00 to 1.00. A one-way analysis of variance (ANOVA) was used to determine the effect of aerobic training, and general exercise training on anxiety as measured by the HAM-A. Within-group differences from baseline to post-training measurements of absence rate were also assessed using the Student's *t*-test (2-tailed) for repeated measures. Statistical significance was accepted at an alpha level of $p < 0.05$ for all analyses.

Results

Attrition rate

Twenty percent of the participants ($n=5$) dropped out before completing the entire 26-week programme. Dropout rates did not vary significantly across interventions. Two participants dropped out because of a medical condition (at the 5th and 8th week respectively of the programme), and three (at the 1st, 2nd and 3rd week respectively) due to a lack of willingness to continue with the programme or because of an unexplained reason. Consequently, out of a total of 24 participants originally selected for the study, only 19 completed the entire programme.

Of these 19 participants (experimental group $n=7$, leisure group $n=5$, control group $n=7$) only 16 also agreed to complete the HAM-A (e.g. 6, 4, and 6, from each group respectively). The three groups were compared according to the HAM-A at the beginning and at the conclusion of the study. From T1 to T2,



there was a statistical significant decrease in HAM-A scores (decrease in the severity of anxiety symptoms) only in the experimental and leisure groups. The patient characteristics and the descriptive

statistics of the study parameters at baseline and at the conclusion of 5 months are shown in Table 1.

Table 1: Baseline data and at the conclusion of 6 months of aerobic training and general exercise (n =16, only participants who completed the programme and the HAM-A questionnaire)

Variable/Time	Exp Group n=6		Leisure Group n=4		Control Group n=6	
	T1	T2	T1	T2	T1	T2
Gender						
Male		2		2		3
Female		4		2		3
Age (y)		47.8±8		50.4±6		51.8±4
Anxious mood	2	1	2	1	2	2
Tension	1	1	2	1	2	2
Fears	2	1	1	1	1	1
Depression	1	0	1	1	1	1
Muscle complaints	1	0	1	0	1	1
Sensation complaints	1	1	1	1	1	1
Total HAM-A score	8	4*	8	5*	8	8

*p<0.05

Discussion

In the authors' earlier work, they showed the effect of physical training on well-being and self-image in older people with ID¹⁰. They hypothesised that improved fitness may be linked to positive changes in psychological well-being, and therefore the present study was conducted to investigate the effects of physical exercise in reducing anxiety among adults with ID. Indeed, they found that the implementation of an aerobic physical training programme or leisure structural activity programme for individuals with ID can significantly reduce the level of anxiety. As such, their hypothesis that foresaw a positive relationship between a psychiatric disorder, such as anxiety, and physical

training could be validated. This finding supports the US Surgeon General's report on physical activity and health undertaken by the US Public Health Service²⁶, which concluded that regular physical activity reduces feelings of depression and anxiety, and promotes psychological well-being in the general population. To the best of these authors knowledge, this study is the first to present information on the effects of physical training on a population of older individuals with ID.

One possible explanation for the observed reduction in anxiety as a result of the physical training is exercise-derived enhancements of participants' actual competency and autonomy as a result of exercising in a positive and mutually



supportive environment where satisfying social interactions are taking place²⁶. In addition, promoting a sense of ownership or control over the workout routine should serve to enhance a sense of responsibility and self-awareness in regard to exercise behaviour and situational control. Moreover, designing a programme that leads the individual to feel successful in mastering the activity should help to develop feelings of competence and reassurance. It is also possible that members of the experimental and leisure groups received more attention, care, praise and approval for participating in the activity programme than the control group. The particular value of exercise might be that it is a controllable stressor. Biological mechanisms appears to affect brain function as a result of its influence on important neurotransmitter chemicals in the central nervous system (i.e. enkephalin, dopamine, serotonin), including alterations in central norepinephrine activity, reduced activity of the hypothalamopituitary-adrenocortical axis, and increased secretion of beta-endorphins. Such molecules are responsible for regulating mood, controlling additional resources and euphoric feelings necessary for social, mental, cognitive and psychological performance^{27,28}. However, this study offers no definitive conclusions about what psychological processes may mediate in anxiety reduction associated with physical activity. The intervention programme in this study had a fair adherence with a good compliance rate. It may sound obvious and insignificant since the participants live in a closed setting and apparently had little choice in attending the programme. Nevertheless, the participants could choose to attend different and equally attractive activities. Therefore the compliance rate was crucial to monitor. Strong and cohesive environmental support enabled the participants to be present almost consistently and continuously throughout the six months of the programme. A supportive network is essential and even critical, since this population can have low self-motivation and a lack of the awareness regarding the benefits of exercise²⁹. On the other hand, it has been previously documented that an interested, challenged and enjoyable physical activity reduced the absentee rate

among exercisers and increased their motivation to participate³⁰. As previously mentioned, people with ID constitute a heterogeneous group. Therefore their physical activity requirements and expected participation rate depend on a plethora of dimensions related to their physical, intellectual, mental, sensory and spiritual abilities. Thus these authors believe that their results could be due to a suitable sample size and low rate of absenteeism in the six months of the programme. Although there was no objective measurement of how participants in the experimental group actually performed the exercises, the positive outcomes on anxiety reduction may indicate that any physical performance may have a beneficial effect on psychological disorders. These authors also did not objectively measure how the exercise programme affected well-being, in terms of enhancing interest in exercise on the part of the participants, voluntary enrolment in other physical activities, and greater awareness and interest in a healthy lifestyle. The retention of the observed outcomes has yet to be investigated. It is not known whether the exercise programme's effects on the participants' anxiety levels demonstrated in this study would still be seen several months after the programme was terminated. The learning capacity and the adjusted ability in older adults with ID are limited, yet it is fair to believe that an ongoing exercise programme may reduce the development of depression and nervousness. Therefore future studies should monitor the long-term effect of such interventions. Finally, a low number of participants is always a barrier and challenge when dealing with such a unique and small portion of the population. Despite the expected dropout of participants, this study found for the first time that physical activity as prescribed in the study protocol can decrease perceived anxiety in persons with ID. Moreover, the positive changes in adults with the dual diagnosis of ID and anxiety support the notion that these unique populations can benefit from an exercise programme and thus should be implemented in ID residential care centres.

In summary, indisputably, exercise provides a vehicle for many specific and



non-specific therapeutic processes, including physiological and psychological benefits and social integration. The results of this study demonstrated that, with an exercise programme over six consecutive months, older adults with ID were able to show anxiety reduction. The mechanism involved in producing such psychological change is unclear and the enduring effects of these interventions should be evaluated once the programme has been completed. Also, because exercise was performed in a group setting, it is possible that the social interaction of study participants may have had a beneficial effect. Nevertheless, exercise is a complex psychobiological stimulus, which changes as its cultural significance changes. Therefore the challenge for future research should be grounded in psychobiological theory, while also being sensitive to the social and cultural context in which the exercise occurs. Thus future research on exercise for ID individuals may need to control for the level of social involvement by examining the effects of the exercise setting (e.g. home- vs. programme-based) on the response to treatment.

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Effects of an exercise programme on anxiety in adults with intellectual disabilities

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ABSTRACT

Although high anxiety is common in people with intellectual disabilities (ID) and the anxiolytic effects of exercise have been systematically recognised in clinical and non-clinical populations, research is scant concerning the role played by exercise on anxiety in people with ID. The purpose of this study was to investigate the effects of a 12-week exercise programme on anxiety states in a group of adults with ID. Twenty-seven individuals with mild to moderate ID were randomly assigned to an exercise group or a control group. The Zung Self-Rating Anxiety Scale adapted for individuals with ID and the State-Trait Anxiety Inventory form Y were used to assess trait and state anxiety. In comparison with the control group, the anxiety scores of people in the exercise group decreased significantly over time.

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1. Introduction

People with intellectual disabilities (ID) are often reported as having high levels of anxiety (Esbensen, Rojahn, Aman, & Ruedrich, 2003; Sravakaki & Lunsy, 2007). Anxiety is characterised by the experience of excessive worry in a number of life domains which appears difficult to control. It is typically accompanied by agitation, feelings of tension and the activation of the automatic nervous system and can have detrimental effects on the skills, performance and daily living functions of ID people (Sravakaki, 1999). Despite the prevalence rate of ID that has been estimated at approximately 1% (American Psychiatric Association, 2000) and the well-recognised risk of high anxiety in this population, research on the assessment and treatment of anxiety in ID individuals has lagged behind that related to the general population (Hagopian & Jennet, 2008).

Physical activity has been widely recognised as an effective strategy in the prevention and treatment of anxiety; regular physical activity and participation in exercise programmes have been shown to reduce both state and trait anxiety and to protect individuals against the onset of anxiety disorders and symptoms (O'Connor, Raglin, & Martinsen, 2000; Physical Activity Guidelines Advisory Committee, 2008). Wipfli, Rethorst, and Landers (2008) conducted a meta-analysis on the anxiolytic effect of exercise mainly in trials involving non-clinical participants, highlighting that exercise is slightly better at reducing anxiety compared to other treatments (effect size = -0.19). Exercise was more effective than stress management education, slightly more effective than stretching and yoga, group therapy, relaxation and meditation, and as effective as cognitive behavioural therapy. Only pharmacological therapy had a small greater effect than exercise. Wipfli et al. (2008), by analysing the role of the duration of the exercise intervention as a moderating variable, found significance for both acute bouts of exercise and exercise interventions lasting 4–15 weeks (effect sizes varied from -0.39 to -0.59). Exercise was also seen to significantly decrease anxiety in different clinically defined populations; positive results have been reported in

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people with cardiovascular diseases (Duarte Freitas et al., 2011), cancer patients (Mehnert et al., 2011), schizophrenic patients (Vancampfort, Probst, et al., 2011) and people with anxiety disorders (Strohle, 2009; Taylor, 2000).

Physical activity is extensively seen to have beneficial effects on mental health in the general population (Penedo & Dahan, 2005), while in individuals with ID it is more likely that physical activity patterns go unnoticed or are not studied because these people are generally not included in large-scale population studies (Temple, Frey, & Stanish, 2006). Nevertheless, published literature suggests that the majority of people with ID are unfit, engage in low levels of daily physical activity and adopt sedentary behaviours (Fernhall & Pitetti, 2001; Graham & Reid, 2000; Rimmer, 2000). The consequence is that high rates of morbidity and mortality related to hypoactive-associated diseases are quoted in this population (Sutherland, Couch, & Iacono, 2002).

Despite the low rate of people with ID regularly engaging in physical activity, the positive effects of participating in physical activity, exercise programmes and sport have been reported in this population (Bartlo & Klein, 2011; Frey, Stanish, & Temple, 2008; Guidetti, Franciosi, Gallotta, Emerenziani, & Baldari, 2010; Rimmer, Chen, McCubbin, Drum, & Peterson, 2010). Physiological, psychological and relational positive outcomes have been described. Functional and musculoskeletal health, such as walking capacity, muscular endurance and strength, flexibility, cardiorespiratory health and functional independence, are the most commonly targeted outcomes (Rimmer et al., 2010). Improvements in quality of life, increased well-being, reduction of maladaptive behaviour, improved cognitive aspects, and amelioration in mental health were noted in different studies (Carmeli, Zinger-Vaknin, Morad, & Merrick, 2005; Elliot, Dobbin, Rose, & Soper, 1994). Improved social relationships and increased self-esteem are reported in studies on sport participation (Guidetti, Franciosi, Emerenziani, Gallotta, & Baldari, 2009).

To the best of our knowledge, only one previous study on the effectiveness of exercise programmes on reducing anxiety in adults with ID has been carried out (Carmeli, Barak, Morad, & Kodesh, 2009). The authors randomly assigned 24 individuals suffering from mild ID and anxiety to one of three groups (aerobic training, physical leisure activity and control). After a 6-month period the participants in the aerobic and leisure groups reported a significant reduction in anxiety.

Starting from this evidence and considering the fact that anxious responses represent a serious problem for individuals with ID, the purpose of this study was to evaluate the effects of a short-term (12 weeks) exercise programme on anxiety states in a group of adults with ID.

2. Method

2.1. Participants

The participants were a group of adults who attended a day centre for people with intellectual and relational disabilities situated in the north-east of Italy. The inclusion criterion was having been diagnosed with mild to moderate mental retardation. The exclusion criteria were having an autism spectrum disorder, presenting diagnosed anxiety or depressive disorders, and the presence of contraindications to moderate intensity exercise.

Twenty-seven people (16 men and 11 women) volunteered to participate in the study. All of the subjects lived at home, and none were institutionalised. The participants' ages ranged from 31 to 49 years ($M = 40.1$, $SD = 6.2$). Eighteen (66.7%) were classified with mild ID and 9 (33.3%) with moderate ID. They were randomly assigned, by means of a random numbers table, to two groups: 13 were in the control group, 14 in the exercise group.

The study was conducted in accordance with the guidelines of the Ethical Committee of the University of Padua, and written informed consent was obtained from all of the participants or from their parents or legal guardians.

2.2. Measures

Each of the participants filled in two self-report anxiety scales: the Italian version of the State-Trait Anxiety Inventory form Y (STAI-Y; Spielberger, 1989) and the Zung Self-Rating Anxiety Scale (SAS; Zung, 1971) adapted for individuals with ID (SAS-ID; Lindsay & Michie, 1988). STAI-Y is a widely used questionnaire developed to measure self-reported trait anxiety (TRAIT-A) and state anxiety (STATE-A), and it is suitable for people with an elementary cultural level, young people, adults and older adults (Potvin et al., 2011). Both scales contain 20 items: the trait anxiety items are rated on a 4-point frequency scale (from 1 for "almost never" to 4 for "almost always"); the state anxiety items are rated on a 4-point intensity scale (from "not at all" to "very"). The range of scores is 20–80 for both the trait scale and the state scale. The participants were asked to respond to each item based on how they felt "at that time" in STATE-A and on how they "generally feel" in TRAIT-A. The SAS-ID is a 20-item scale used with a "yes/no" response format that is more reliable than the original 4-point format (Lindsay, Michie, Baty, Smith, & Miller, 1994; Ramirez & Lukenbill, 2008) because it is easily understandable. The responses were then scored using 1 or 2 as a "no/yes" presentation. The range of scores is 20–40, in which higher scores correspond to a greater perception of generalised anxiety. To reduce the effect of a response bias, five items are reversed.

2.3. Procedure

The intervention lasted 12 consecutive weeks. Individuals in the exercise group participated in a physical exercise programme, while those in the control group participated in a painting activity programme. Painting activities were chosen

because of the low level of social interaction and because physical involvement is minimal. Both groups were engaged in two one-hour sessions per week. The participants were informed that they would be able to withdraw from the programme whenever they wished.

Measures were collected at the baseline (T0), at the middle term after 6 weeks (T1) and at the end of the intervention after 12 weeks (T2). The TRAIT-A and SAS-ID scales were administered on days when the participants were not involved in the experimental or control activities; the STATE-A scale was completed just before (pre) the session and immediately after it (post) at T0, T1 and T2.

2.4. Exercise protocol

Physical exercise sessions were conducted by an exercise specialist who was supported by two tutors to better sustain individual participation. Group-based movement situations were proposed, and the intensity and duration were adapted according to the participants' skills and physical fitness. Each session had a standardised structure, with an initial warm-up phase, a central phase in which the main topic was developed, and a cool-down phase including group discussion and individual comments. A warm-up was carried out to activate physiological responses and to help the participants focus their attention through low-intensity movement. The central phase of a session consisted of individual or in pair movement using different equipment (e.g. balls, ropes, dumbbells, etc.), group cooperative situations and adapted games. During the cool-down phase simple relaxation and breathing exercises were proposed. A short group discussion, using the circle time technique, was included at the end of the sessions.

2.5. Statistical analysis

Cronbach's α was calculated to assess the internal consistency of the STAI-Y scales.

Means and standard deviations of STAI-Y scores for TRAIT-A and STATE-A (pre and post), and SAS-ID scores were calculated at the different times of the intervention. Independent samples *t*-tests were conducted to compare the baseline STAI-Y and SAS-ID scores of the control group and the exercise group, of participants diagnosed with mild or moderate ID, and by gender.

The TRAIT-A convergent validity was investigated by Pearson's correlation between TRAIT-A and SAS-ID.

ANOVA for repeated measures was conducted on the TRAIT-A and SAS-ID scores to examine the effects of exercise on trait and generalised anxiety during the intervention.

Scores on STATE-A were analysed using a $2 \times 2 \times 3$ mixed-model design ANOVA with group (experimental and control), test (post versus pre) and time (T0, T1, T2) as factors. Moreover, for STATE-A scores we calculated the pre- and post-test relative variations and the effect sizes according to the formula indicated by Becker (1988).

A significance level of $p \leq 0.01$ was accepted.

3. Results

The Cronbach's α of the STAI-Y were satisfactory, with mean values of .96 for TRAIT-A and .97 for STATE-A. At the baseline the comparison between the exercise group and the control group did not result in any significant differences regarding SAS-ID, TRAIT-A or STATE-A. No significant differences were found among the participants diagnosed with mild or moderate ID or by gender.

Pearson's correlations between TRAIT-A and SAS-ID were statistically significant ($p < .001$) at T0, T1 and T2 ($r = .87$, $r = .84$, $r = .93$, respectively), lending support for the convergent validity of TRAIT-A with a scale specifically adapted for people with ID.

The repeated-measures ANOVA showed a significant reduction in the exercise group compared with the control group in TRAIT-A ($F(1, 25) = 44.44$, $p < .001$) and SAS-ID ($F(1, 25) = 23.01$, $p < .001$) during the intervention. The descriptive statistics are reported in Table 1.

The results from the mixed-model design ANOVA indicated that the post- versus the pre-scores of STATE-A at T0, T1 and T2 were significantly different ($F(2, 24) = 16.75$, $p < .001$), with major effects in the exercise group. The mixed-model design ANOVA also showed a significant difference in the analysis of group $\times$ test $\times$ time ($F(2, 24) = 20.49$, $p < .001$) in the STATE-A scores. The participants in the exercise group reported a significantly lower level of STATE-A ($F(1, 25) = 99.02$, $p < .001$). The descriptive statistics, relative variations and effect size scores for STATE-A are reported in Table 2.

4. Discussion

The anxiolytic effects of exercise in the general population and in clinically defined groups have been well established in several studies over the past decades (O'Connor et al., 2000). Exercise has also been seen to have an anxiety-reducing effect in people with ID (Carmeli et al., 2009). The aim of the present study was to evaluate the effects of a short-term exercise programme on anxiety states in a group of adults with mild to moderate ID. The participants were randomly assigned to a 12-week exercise programme or to a control group (painting activities). Those in the exercise group reported significant

Table 1
Changes in TRAIT-A and SAS-ID over time.

	TRAIT-A		SAS-ID	
	Exercise group M (SD)	Control group M (SD)	Exercise group M (SD)	Control group M (SD)
T0	59.9 (2.9)	59.8 (4.3)	33.86 (1.99)	33.46 (1.94)
T1	50.6 (5.2)	59.0 (4.6)	29.79 (2.33)	32.92 (2.69)
T2	38.1 (2.5)	57.2 (4.3)	25.00 (1.62)	31.62 (1.94)

Note: T0, baseline; T1, after 6 weeks; T2, after 12 weeks.

Table 2
STATE-A scores over time, pre- and post-activity sessions.

	Exercise group			Control group			d
	Pre M (SD)	Post M (SD)	Δ	Pre M (SD)	Post M (SD)	Δ	
T0	56.9 (4.4)	40.9 (5.9)	–28.3%*	59.9 (7.4)	57.0 (6.7)	–4.8%*	–3.2
T1	47.8 (6.8)	31.3 (4.6)	–34.5%*	60.2 (6.7)	55.5 (5.7)	–7.9%*	–1.7
T2	35.9 (3.8)	27.1 (3.3)	–24.2%*	59.2 (5.8)	54.9 (5.6)	–7.1%*	–1.6

Note: T0, baseline; T1, after 6 weeks; T2, after 12 weeks.

* $p < 0.01$.

reductions in generalised, trait and state anxiety compared to those in the control group, as measured by SAS-ID, TRAIT-A and STATE-A.

At the baseline the STAI-Y scores of the participants showed higher values for both trait anxiety and state anxiety in comparison with normative data estimated from general adult population samples (Crawford, Cayley, Lovibond, Wilson, & Hartley, 2011; Spielberger, 1989). At the end of the intervention anxiety states of participants in the exercise group decreased significantly, reporting data comparable with those registered for the general adult population.

The results of the present study indicate that exercise seems to be more effective than a control activity in reducing anxiety in people with ID. Generalised and trait anxiety, measured respectively by SAS-ID and the trait scale of STAI-Y, showed a significant reduction in the exercise group compared to the control group. The findings support the notion that exercise has similar positive effects on anxiety in people with ID over short-term programmes as those reported in the general population and in clinically defined groups (DiLorenzo et al., 1999; Khan, Marlow, & Head, 2008; Wipfli et al., 2008).

Changes in state anxiety after single exercise sessions have been shown in clinical and non-clinical populations (Abrantes et al., 2009; Biddle & Mutrie, 2008; Vancampfort, De Hert, et al., 2011). In our study, state anxiety, measured in pre and post single sessions by STATE-A, decreased significantly both in the exercise group and in the control group, but the magnitude of the difference for participants in the exercise group was higher. Furthermore, over time the participants in the exercise group showed a significant decrease in the STATE-A scores registered before the exercise sessions. These findings seem to support the idea that the effects of exercise remain over time and may lead to reduced psychological arousal and distress.

In the proposed exercise intervention a combination of factors (e.g. physical involvement, experience of skills improvement, muscular relaxation and social relationships mediated by the body) could have induced an anxiety-reducing effect. Despite an increasing amount of research that has reported the anxiolytic effects of exercise, no single theory adequately explains how exercise leads to a reduction in anxiety states (Dunn, Trivedi, & O'Neal, 2001; Markowitz & Arent, 2010). Anxiety itself has multiple aetiologies, including psychological and biological aspects, so it is complicated to establish what the mechanism is that causes physical activity to induce beneficial effects on anxiety. The Surgeon General's Report on Mental Health documented that anxiety has a biochemical basis found in the brain (U.S. Department of Health and Human Services, 1999), so for this reason it is plausible that exercise can induce biological changes associated with anxiety reduction. However, there is a need to investigate further the mechanisms that are involved in anxiety responses in order to better adapt the type and duration of the exercise in people with ID.

5. Conclusions

The present study reported that a short-term exercise programme could reduce anxiety states in people with ID more than a sedentary activity. Results support the notion that exercise could be considered to be a valid strategy to promote mental health in people with ID. Moreover, implementing lifestyle interventions based on physical activity could be a cost-effective strategy in promoting individual health and wellbeing (Verhaeghe, De Maeseneer, Maes, Van Heeringen, & Annemans, 2011). Future research should include a follow-up evaluation to assess whether improvements in anxiety are maintained after a period without exercise. Another important direction of the research could be focused on evaluating which mechanisms or variables are more involved in the reduction of anxiety levels during and after exercise.

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Could sport specialization influence fitness and health of adults with mental retardation?

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ABSTRACT

Although several studies showed the positive effects of exercise and physical activity on health and well-being for individuals with ID, there is a lack of information about the influence of sport specialization on fitness and health components. Therefore, the aims of this study were to assess: (a) physical fitness of athletes with intellectual disability (ID) compared with individuals included in recreational and leisure activity programs (non-athletic people); (b) contribution of sport specialization on athletes' fitness; and (c) correlation of each fitness variable with subjects' ID levels. Twenty-two track and field, 19 basketball, and 23 non-athletic adults were recruited. Before and after a 9-month period, all participants performed fitness tests assessing body composition, flexibility (SR), arm muscular strength (HG), lower and upper-body muscular strength and endurance (SUP and PUP), explosive leg power (SLJ), cardiovascular endurance (ST), balance ability (FT), motor coordination (TUGT). The results showed that participants' weight, BMI and FT were significantly affected by time; SLJ by activity; ST, HG, PUP, SUP, and TUGT by both time and activity. Only track and field athletes increased significantly ST. All athletes improved significantly HG, PUP and SUP, instead non-athletic people decreased significantly SUP ($p < 0.01$). TUGT improved significantly in track and field athletes ($p < 0.05$), and decreased significantly in non-athletic people. ID level was positively correlated to TUGT. Findings of this study showed that physical activity improved fitness in adult athletes with ID, decreasing health risks. Athletes with lower ID obtained higher performance scores in motor coordination test.

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1. Introduction

Many studies reported that individuals with intellectual disability (ID) demonstrated poor levels on standard fitness tests, in particular on measures of cardiovascular endurance, body composition, muscular endurance and strength, and motor coordination (Carmeli, Bar-Yossef, Ariav, Levy, & Liebermann, 2008; Chanas, Reid, & Hoover, 1998; Frey, Stanish, & Temple, 2008; Graham & Reid, 2000; Van de Vliet et al., 2006). The low levels on fitness tests could be attributed to: (a) sedentary life and fewer opportunities for participation in structured physical activity programs; (b) physical characteristics such as short stature; (c) lack of coordination and efficiency; (d) infrequent opportunities to practice test items; and (e) lack of motivation during testing and tendency to stop when uncomfortable (Graham & Reid, 2000). Therefore, improved fitness should promote an active lifestyle, decrease health risks, and increase work capacity, which may further decrease the need for

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premature institutionalization (Chanas et al., 1998; Frey et al., 2008). Determinants that define health-related physical fitness are body composition, cardiovascular endurance, flexibility, muscular endurance, and muscular strength (Chanas et al., 1998). There is a general perception that the prevalence of overweight status/obesity is greater among people with ID than those without disability. Inactivity and inappropriate eating habits may be the major causes of the high obesity rates of individuals with ID (Podgorski, Kessler, Cacia, Peterson, & Henderson, 2004). Therefore, people with ID generally demonstrate improved health-related physical fitness parameters when exposed to structured exercise regimes (Chanas et al., 1998).

Many facets such as working, maintaining a household, cooking, self-caring, and recreation require the individual to possess a certain degree of physical stamina. People with ID need an adequate amount of fitness to contribute to work-related tasks and enjoy and to benefit from participation in recreational and leisure activities (Graham & Reid, 2000). Unfortunately, several barriers, as segregated environments, have been noted to inhibit successful promotion of skill development and programming (Whorton et al., 1994).

Therefore, sport can help people with ID to increase their self-esteem and it can be fundamental for socialization and cooperation with other people who lives the same disease (Guidetti, Franciosi, Emerenziani, Gallotta, & Baldari, 2009). Team sports, such as basketball, can be a popular way for individuals with ID to get involved in physical activity. Basketball is a common activity for people with ID, because it incorporates both motor skills (e.g. running, jumping, shooting) and social aspects (Baldari et al., 2009). The practice of adapted basketball training might improve the social relationships, because problems of interpersonal interaction are common in adults with ID (Guidetti et al., 2009). This is in close relationship with the nature of the basketball performance in which person–environment interaction, high decision-making processes, and comprehension of game situations are very important (Wang, Chen, LiDoongreungrat, & Change, 2005). Moreover, sport through a standard training and competition could be useful for testing personal limits and pursuing athletic dreams and goals (Van de Vliet et al., 2006). Track and field, for example, has become one of the most popular individual sports for people with ID, both for recreational reasons and for motor skills and fitness development.

Although several studies showed the positive effects of exercise and physical activity on health and well-being for individuals with ID (Frey et al., 2008; Van de Vliet et al., 2006), there is a paucity of information about the influence of sport specialization on fitness and health components. Therefore, the aims of this study were to assess: (a) the physical fitness profile of athletes with ID in comparison to individuals with ID included in recreational and leisure activity programs (non-athletic people); (b) the contribution of sport specialization on athletes' fitness; and (c) the correlation of each fitness variable with subjects' ID levels.

2. Methods

2.1. Participants

Sixty-four subjects with ID aged 18–45 years volunteered to participate in this study. The sample was composed by 22 track and field athletes, 19 basketball players, and 23 non-athletic people.

The track and field athletes' height, weight and BMI were 164.7 ± 9.8 cm, 74.9 ± 14.9 kg, 27.6 ± 4.9 kg/m², respectively. The basketball players' height, weight and BMI were 164.9 ± 8.2 cm, 78.9 ± 12.9 kg, 29.1 ± 5.1 kg/m², respectively. The non-athletic people's height, weight and BMI were 160.9 ± 7.6 cm, 68.5 ± 13.6 kg, 26.9 ± 6.0 kg/m², respectively.

All subjects lived at home or in group settings, and none was institutionalized. They were classified as having mild (38%), moderate (22%), severe (38%) and profound (3%) ID. The eligibility criteria included: (a) a diagnosis of MR; (b) age range 18–45 years; and (c) an athletic eligibility. The study was approved by the Institutional Review Board for Human Subjects of University of Rome "Foro Italico", and written informed consent was obtained from all participants and from their parents or their legal guardians (if indicated) after a detailed description of the procedures was provided.

2.2. Experimental protocols

The experimental protocol was conducted in three different periods. In the first period, all subjects passed a compulsory medical-psychiatric examination conducted by a mental health staff to assess athletes' ID level and a physical examination performed by a specialist in sports medicine for athletic eligibility. Moreover, all subjects were assessed before (Pre) the specific intervention period through fitness and coordinative tests.

In the second period, track and field athletes participated in a 9 months specific training program of 3 h per week. The training was composed in two phases, as follows: (I) all athletes performed exercises to improve muscular strength, aerobic power, speed, flexibility, and coordinative skills; and (II) each athlete performed a specific training according to the selected competitions they would participate to. Basketball players participated in a 9 months specific training program of 3 h per week. Basketball training was divided in four phases and it could be altered following the coaches' aim during the training session. Each phase required a different type of weight training and conditioning program for players to follow and it was designed to prepare players for the rigours of training and game play (Baldari et al., 2009). Non-athletic people participated in 9 months recreational and leisure activity program.

In the third period, all subjects were assessed after (Post) the specific intervention period through fitness and coordinative tests.

2.3. Exercise testing and measurements

Prior to performing the anthropometric measures, fitness and coordinative test battery, participants had a variable number of familiarization sessions depending on how fast they became accustomed to field tests. These trials were helpful in teaching the participants the correct execution of the exercise.

Anthropometric measurements, physical fitness and coordinative abilities were assessed through modified and validated test battery for individuals with ID (Carmeli, Zinger-Vaknin, Morad, & Merrick, 2005; Eurofit, 1988; Gordon, Chumlea, & Roche, 1988; Government of Canada, 1986; Montgomery, Reid, & Seidl, 1988; Van de Vliet et al., 2006).

Pre- and post-intervention anthropometric measurements assessed participants' weight, height, BMI and body fat. Weight and height were measured using a scale and a stadiometer to the nearest 0.2 kg and 0.1 cm, respectively. Biceps, triceps, sub scapular and suprailiac thickness was measured to the nearest 0.2 mm using a calliper (Harpندن, St Albans, UK) on the right side of the body. All skin folds were taken three times by the same experimenter to ensure consistency in results with the average of the three values used as a final value. To predict body fat (%FM) the equation described by Durnin and Womersley (1974) was selected for this investigation.

Pre- and post-intervention tests, assessing participants' physical fitness and coordinative abilities, included:

- The *Step test* to assess cardiovascular endurance. Participants were required to ascend and descend two steps at a pre-established tempo heard on a metronome. The initial tempo was determined by the participant's age. It was possible to complete 3-min workloads if the individual's heart rate did not exceed a target level after each workload. When the three minutes were up, the participant was instructed to remain motionless. A 10 s post-exercise heart rate was recorded. Therefore, the results of the step test were placed into a regression equation provided by Jette, Campbell, Mongeon, and Routier (1976) and used to predict the maximum oxygen uptake ($\dot{V}O_{2\max}$).
- The *standing long jump test* to assess explosive leg power. Participants stood at a starting line marked on the ground with feet slightly apart. A two-foot take-off and landing were used, with swinging of the arms and bending of the knees to provide forward drive. The longest distance jumped was measured in centimeters, the better of two trials.
- The *hand grip test* to assess grip or forearm muscular strength. The subject held the dynamometer in the hand to be tested. The best score for each hand was added and recorded as a single score to the nearest kilogram.
- The *sit-ups and push-ups tests* to measure lower and upper-body muscular strength and endurance, respectively. In the push-ups test, participants were instructed to perform consecutively as many push-ups as possible. The score was the number of successfully completed push-ups. In the sit-ups test, participants were instructed to complete as many sit-ups as possible in one minute. The score was the number of correctly performed sit-ups.
- The *timed up and go test* to assess motor coordination (dynamic balance and gait speed). Participants were asked to rise from an armchair, walk 9 m, and return to the chair (total walking distance of 18 m). The test was scored in seconds. Shorter time indicated higher performance.
- The *flamingo test* to assess the ability to stand successfully on a single leg. The number of trials that the subject needed to complete in 1 min (the chronometer was stopped whenever the subject did not comply with the protocol conditions) was measured. The outcome was expressed as number of trials (number of falls).
- The *sit-and-reach test* to assess lower back and hamstring flexibility. Participants were instructed to reach as far as possible with the legs straight while sitting at a sit-and-reach box. The score was recorded to the last whole centimeter. The best of two trials was reported.

Table 1
Significant ANOVA results in anthropometric, fitness and coordinative ability measures.

Measures	Factors	F	p
Weight (kg)	Intervention	113.22	<0.0001
BMI (kg/m ²)	Intervention	11.94	<0.01
Step test (ml/kg/min)	Group × intervention	4.38	<0.05
Flamingo test [$\sqrt{(\text{num})}$]	Intervention	8.57	<0.01
Standing long jump test (cm)	Group	6.72	<0.01
Hand grip (kg)	Group	6.20	<0.01
	Intervention	20.04	<0.0001
	Group × intervention	6.42	<0.01
Push-up (num)	Group	11.06	0.0001
	Intervention	25.37	<0.0001
	Group × intervention	4.58	<0.01
Sit-up (num)	Group	11.47	<0.0001
	Intervention	14.168	0.0005
	Group × intervention	10.86	<0.0001
Timed up and go test (s)	Group × intervention	5.70	<0.01

Table 2
Pre- and post-test (mean values $\pm$ SD) in track and field athletes, basketball players and non-athletes.

Measures	Track and field athletes		Basketball players		Non-athletic people	
	Pre	Post	Pre	Post	Pre	Post
Weight (kg)	74.9 $\pm$ 14.9	71.4 $\pm$ 14.0**	78.9 $\pm$ 12.9	75 $\pm$ 12.9**	68.5 $\pm$ 13.6	65.4 $\pm$ 13**
Height (cm)	164.7 $\pm$ 9.8		164.9 $\pm$ 8.2		160.9 $\pm$ 7.6	
FM (%)	29.6 $\pm$ 6.2	29.6 $\pm$ 6.7	26.3 $\pm$ 8.7	26.5 $\pm$ 7.8	29.5 $\pm$ 7.6	29.5 $\pm$ 7.7
BMI (kg/m ²)	27.6 $\pm$ 4.9	26.3 $\pm$ 4.7**	29.1 $\pm$ 5.1	27.7 $\pm$ 5.0**	26.9 $\pm$ 6.0	25.7 $\pm$ 5.8**
ST (ml/kg/min)	24.9 $\pm$ 4.6	26.4 $\pm$ 4.7*	25.5 $\pm$ 4.9	26.3 $\pm$ 4.8	26.2 $\pm$ 2.9	25.4 $\pm$ 3.2
FT [$\sqrt{\text{num}}$]	2.3 $\pm$ 1.3	1.4 $\pm$ 1.3*	2.2 $\pm$ 0.8	1.4 $\pm$ 1.7	2.8 $\pm$ 1.9	2.7 $\pm$ 1.8
SLJ (cm)	111.4 $\pm$ 38.1	109.2 $\pm$ 40.4	119.7 $\pm$ 38.7	117 $\pm$ 26.4	75.6 $\pm$ 32.0	76.7 $\pm$ 44.4
SR (cm)	17.3 $\pm$ 7.7	18.3 $\pm$ 7.3	17.2 $\pm$ 7.4	17.4 $\pm$ 5.1	19.1 $\pm$ 9.1	18.4 $\pm$ 7.6
HG (kg)	25.6 $\pm$ 14.8	35.0 $\pm$ 23.2*	27.3 $\pm$ 14.1	37.4 $\pm$ 16.5**	15 $\pm$ 16.3	14.4 $\pm$ 16.5
PUP (num)	20.3 $\pm$ 12.9	33 $\pm$ 12.6*	20.3 $\pm$ 12.3	27.1 $\pm$ 10.7*	11.1 $\pm$ 8.9	13.5 $\pm$ 7.5
SUP (num)	18.6 $\pm$ 6.3	24.3 $\pm$ 6.9**	19.6 $\pm$ 7.4	25.4 $\pm$ 6.5**	12.9 $\pm$ 9.4	10.6 $\pm$ 9.6**
TUGT (s)	13.5 $\pm$ 4.2	12.6 $\pm$ 4.2*	13.0 $\pm$ 3.0	13.2 $\pm$ 3.9	12.9 $\pm$ 3.8	15.1 $\pm$ 3.3*

FM, body fat; BMI, body mass index; ST, step test; FT, flamingo test; SLJ, standing long jump test; SR, sit-and-reach test; HG, hand grip test; PUP, push-ups test; SUP, sit-ups test; TUGT, timed up and go test.

* $p < 0.05$ Post vs. Pre.

** $p < 0.01$ Post vs. Pre.

Anthropometric measurements, physical fitness and coordinative tests had a high reliability in people with ID (ICC range 0.90–0.99) (Berg & Norman, 1996; Mac Donncha, Watson, McSweeney, & O'Donovan, 1999; Montgomery, Reid, & Seidl, 1988).

ID level was assessed by mental health specialists throughout a medical-psychiatric examination.

2.4. Statistical analysis

The means and standard deviations of the selected variables [anthropometric measurements (height, weight, BMI, %FM), cardiovascular endurance (predicted $\dot{V}O_{2\max}$), lower back and hamstring flexibility, explosive leg power, static balance ability, forearm muscular strength, motor coordination, muscular strength and endurance] were calculated.

Individual scores were analyzed using a 3×2 mixed-model ANOVA with group (track and field athletes, basketball players, non-athletic people) and intervention (Post vs. Pre) as factors. Post hoc assessment of significant F ratios was undertaken by means Fisher's test.

Moreover, for each test scores evaluated after the intervention period, we calculated the absolute variation (Δ) with respect to its pre-intervention value (Post-intervention–Pre-intervention value). The Spearman's correlation was then performed to examine the relationship of ID level to fitness and coordinative changes (Δ) following the intervention period.

A significance level of $p \leq 0.05$ was accepted.

3. Results

Table 1 reports only ANOVA significant results that are relevant for the present study: Main effects of group, Intervention, and group $\times$ intervention interactions. Particularly, weight, BMI and static balance ability significantly change after the intervention period regardless the group.

The standing long jump test scores are significantly affected by the group regardless the Intervention, showing that track and field and basketball subjects' explosive leg power performances are higher than non-athletic people's performances.

As Table 2 shows, only the track and field athletes improved significantly the predicted $\dot{V}O_{2\max}$ value. Both track and field athletes and basketball players increased significantly their strength performances (hand grip, push-ups, sit-ups tests) compared to non-athletic people who decreased significantly the sit-ups test score. Finally, the motor coordination test increased significantly in track and field athletes and decreased significantly in the non-athletic group.

The application of Spearman's correlation analysis indicated that ID level was positively correlated with the coordinative changes (Timed up and go test Δ) following the intervention period ($p < 0.01$, $R = 0.40$), revealing that people with lower ID obtained higher ability score in motor coordination.

4. Discussion

The first aim of this investigation was to assess the physical fitness profile of athletes with ID in comparison to individuals with ID included in recreational and leisure activity programs. Several measures changed after the intervention period regardless the group. In particular, body weight and BMI decreased significantly in all three groups. It could be explained by the positive influence of physical activity in athletes and recreational activity in non-athletic people on these anthropometric variables. Many studies reported that individuals with ID demonstrate poor fitness level related to measures of body composition (Chanias et al., 1998; Fernhall, 1993; Graham & Reid, 2000; Van de Vliet et al., 2006) showing the need to

participate in physical activity programs to improve body composition and consequently physical activity or sport performance.

The second aim of this investigation was to assess the contribution of sport specialization on athletes' fitness. Track and field athletes improved the static balance ability, confirming Carbonaro's study (2000), in which track and field athletes without disability showed better body balance than other sport groups. Although people with ID present problems to perform body balance tests, the specific training could improve this ability in athletes with ID (Carmeli et al., 2005). Carbonaro, Merni, and Madella (2000) showed that track and field athletes without disability had better performance in explosive leg strength than basketball players without disability. In our study this difference was not present. However, both track and field athletes and basketball players performed significantly better on leg power test than non-athletic people. This result could be explained by the training program in athletic groups. Track and field and basketball are sports based around total body explosive movements.

It has been recognized that individuals with ID show low levels of cardiovascular endurance (Graham & Reid, 2000). In this study, the significant improvement following the intervention period of predicted $\dot{V}O_{2\max}$ was found only in track and field athletes, and it could be probably due to the specific track and field races (e.g. 400 m in walking) training. No significant result in cardiovascular endurance test was probably due to low level of ability in basketball players. All basketball players recruited in this investigation, in fact, took part in no agonistic events. However, the mean $\dot{V}O_{2\max}$ values of both athletic groups were very low (25.7 ± 4.3 ml/kg/min in Pre-test; 26.3 ± 4.2 ml/kg/min in Post-test), confirming that individuals with ID exhibited much lower levels of cardiovascular performance when compared to persons without disability (Guerra, Llorens, & Fernhall, 2003; Kittredge, Rimmer, & Looney, 1994; Pitetti, Yarmer, & Fernhall, 2001; Rimmer, 1992). This may be partly due to poor physical activity habits and sedentary lifestyles observed in this population (Kittredge et al., 1994) and partly to the difficulty with maintaining a stepping cadence especially at the faster cadences during the execution of step test (Reid, Montgomery, & Seidl, 1985; Seidl, Reid, & Montgomery, 1987). Indeed, the limited mental ability and short attention span in people with ID, the difficulty in understanding and following test directions, the lack of motivation to try the best during testing (Eichstaedt & Lavay, 1992) could induce performing test problems.

All athletes improved significantly the forearm, lower and upper-body strength and endurance following the training period. These results confirmed the importance of muscular strength and endurance components both in track and field and basketball sport. Conversely, non-athletic people showed a significant decrease in sit-ups but almost no change in push-ups due to the higher opportunity to use the upper limb muscles than trunk muscles during daily activities (Graham & Reid, 2000).

Some studies showed that individuals with ID, with a reduction of adaptability provoked by the permanent loss of certain capacities, present various difficulties in motor abilities such as writing, handling objects, running, jumping, hopping, throwing, balance, space and time orientation, side movements, sports and even movement and daily activities (McKinlay, Bradley, Hindle, & Ehrhardt, 1987). Therefore, individuals with ID present lack of coordinated movements, since they have problems with processing information and lack of ability (Bertini, 2005; Bouffard & Wall, 1990; Graham & Reid, 2000). Findings of the present study showed a significant difference between athletic and non-athletic group in motor coordination test. Specifically, track and field athletes improved coordinative performance after the intervention period while non-athletic people decreased. The athletes' improvement could be caused by the high coordinative component of sports such as track and field and basketball (Starosta, 2000). Therefore, findings of this study confirmed the positive influence of physical activity on fitness in people with ID in relation to sport specialization. The third aim of this study was to analyse the correlation of each fitness variable with subjects' ID levels. ID level was positively correlated to motor coordination, indicating that athletes with lower ID obtained higher performance scores in motor coordination. In the timed up and go test, in fact, a shorter time indicated higher performance. Moreover, several studies showed that ID degree has an effect on performance (Lahatinen, Rintala, & Malin, 2007). Persons with ID have poor gross motor control that affect performance on physical fitness tests, resulting in lower fitness measures (Seidl et al., 1987).

5. Conclusions

This study showed that specific sport training could improve fitness of individuals with ID more than recreational and leisure activity program. Improved fitness should promote an active lifestyle, decrease health risks, increase work capacity, physical and emotional well-being (Chanas et al., 1998; Fernhall, 1993; Frey et al., 2008). Future research should include the investigation of sport training regimes to help individuals with ID to perform successfully in their performance. In fact, sport through a standard training and competition could be useful for testing personal limits and pursuing athletic dreams and goals (Van de Vliet et al., 2006). Moreover, the results of this study showed that it is necessary to include the sport programs in recreational and leisure activity program for people with ID to reach an adequate amount of fitness to contribute to work-related tasks and enjoy and benefit (Graham & Reid, 2000).

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ORIGINAL ARTICLE

Effects of Combined Aerobic and Resistance Exercise Training in Adults With and Without Down Syndrome

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ABSTRACT. Mendonca GV, Pereira FD, Fernhall B. Effects of combined aerobic and resistance exercise training in adults with and without Down syndrome. *Arch Phys Med Rehabil* 2011;92:37-45.

Objective: To determine whether adults with Down syndrome (DS) could improve their submaximal and peak exercise capacity, as for adults without disabilities, after 12 weeks of combined (aerobic and resistance) exercise training.

Design: Prospective study comparing the effects of a 12-week combined exercise program on submaximal and peak exercise capacity of adults with and without DS.

Setting: University facilities.

Participants: Participants with DS ($n=13$; mean $\pm$ SD age, 36.5 ± 5.5 y) and participants without disabilities ($n=12$; mean age, 38.7 ± 8.3 y).

Interventions: Combined exercise training for 12 weeks. Endurance training was performed 3 days a week for 30 minutes at 65% to 85% of peak oxygen consumption ($\text{VO}_{2\text{peak}}$). Resistance training was prescribed for 2 days a week and consisted of 2 rotations in a circuit of 9 exercises at 12-repetition maximum.

Main Outcome Measures: Submaximal and maximal graded exercise tests with metabolic and heart rate measurements. Walking economy and $\text{VO}_{2\text{peak}}$ were considered the main outcomes.

Results: Participants with DS and those without disabilities showed similar values for body mass index and relative fat mass at pre- and posttraining periods. Walking economy and $\text{VO}_{2\text{peak}}$ overall were lower in participants with DS than participants without disabilities ($P<.05$). Training improved walking economy and $\text{VO}_{2\text{peak}}$ in participants with DS and those without disabilities ($P<.05$); additionally, the magnitude of changes induced by training was similar between groups.

Conclusions: Overall, a 12-week combined exercise regimen induced gains of similar magnitude between adults with and without DS for submaximal and peak exercise capacity.

Key Words: Down syndrome; Exercise; Rehabilitation; Training.

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DOWN SYNDROME is the most commonly inherited form of developmental disability in North America.¹ It is estimated that DS will be diagnosed in 1 of every 700 to 1000 newborns in the United States, and there currently are 350,000 persons with DS living in the United States.¹ In more than 90% of cases, DS results from an excess of genetic material from chromosome 21 (ie, trisomy 21). Numerous studies have shown that persons with DS have diminished work capacity, concomitant with decreased $\text{VO}_{2\text{peak}}$ ^{2,3} and low levels of muscle strength.⁴⁻⁶ More recently, it also was shown that adults with DS have decreased walking economy and thus an impaired response to submaximal exercise.^{7,8} Taken together, such findings suggest that persons with DS might be particularly susceptible to loss of basic function because of poor physical fitness.^{5,6,9-11}

To our knowledge, few prospective studies have examined the effects of structured exercise training in persons with DS, and their findings are somewhat contradictory. Millar et al¹² observed increases in work capacity, but no change in $\text{VO}_{2\text{peak}}$ of 14 adolescents with DS after 10 weeks of aerobic training. These findings subsequently were confirmed by Varela et al¹³ after a 16-week rowing program. Accordingly, this led the investigators to speculate that the capacity for improving aerobic functioning in persons with DS might be limited. Nevertheless, both studies reported gains in exercise endurance after training, but they were unable to provide a definite explanation for these findings.

More recently, Tsimaras et al¹⁴ were the first to document a significant increase in $\text{VO}_{2\text{peak}}$ in adults with DS after an aerobic training regimen consisting of 3 sessions a week for 12 weeks. Similar findings were reported after 12 weeks of a combined exercise program in older adults with DS¹⁵ and after 28 weeks of multi-ergometer aerobic conditioning.¹⁶ Consequently, given these latest reports, there is evidence that adults with DS respond positively to structured exercise training, particularly under well-controlled conditions, and this is supported further by the meta-analytic findings of Dodd and Shields.¹⁷ Importantly, only 4 trials^{15,18-20} have investigated whether persons with DS have the capacity to improve their levels of muscle strength in response to progressive resistance training. Three of these trials¹⁸⁻²⁰ included progressive resistance training, and 1¹⁵ used a combined exercise program.

List of Abbreviations

ANOVA	analysis of variance
ATP	adenosine triphosphate
BMI	body mass index
BSA	body surface area
DS	Down syndrome
FU	fractional utilization
RER	respiratory exchange ratio
RM	repetition maximum
VO_2	oxygen consumption
$\text{VO}_{2\text{peak}}$	peak oxygen consumption

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Overall, findings indicated that programs prescribed for a frequency of 3 days a week improved the upper- and lower-limb muscle strength of persons with DS.^{15,18,19} In contrast, training regimens of lower frequency (2d/wk) apparently were associated with gains in upper-limb muscle endurance.²⁰

Unfortunately, none of these training studies compared relative gains in physical fitness of people with DS with those of a nondisabled group of similar characteristics. Considering the differential training responses of previous studies in persons with DS, it would be important to explore whether adults with DS showed a different pattern of response to training than adults without disabilities. Furthermore, it is not known whether exercise training is an effective intervention for improving the walking economy of adults with DS. A combination of resistance training and endurance training enhanced exercise performance and economy in healthy adults²¹; however, this has never been explored in persons with DS. Consequently, the main purpose of this study was to determine whether 12 weeks of combined exercise training, using both aerobic and resistance exercise, produces differential responses in exercise economy and peak exercise capacity in adults with and without DS.

METHODS

Healthy participants (N=25; 13 with DS [10 men, 3 women], 12 without disabilities [9 men, 3 women]; age, 27–50y) were included in the present study. A health screening questionnaire was completed by each participant and/or a parent or legal guardian. As in previous studies, exclusionary criteria included contraindications to exercise; severe or profound intellectual disability; active smoking status; congenital or atherosclerotic heart disease; metabolic disease; respiratory disorders, including asthma; atlantoaxial instability; orthopedic issues that would limit treadmill performance; and heart rate-altering medications.⁶ In addition, all participants had normal thyroid function according to a family member or physician report. Participants in both groups were either sedentary or moderately active, but none was involved in a formal exercise endurance training for at least 6 months. All participants and parents and/or guardians of participants with DS signed informed consent to participate in the study. Informed consent was attained after listening to an explanation of the nature of study participation and initial eligibility screening. Additionally, before signing the informed consent, participants were given the opportunity to visit the facilities at which testing and exercise sessions would be conducted. This study was approved by the university's Institutional Review Board.

Participants with DS were recruited from a vocational center for adults with intellectual disabilities. They all lived at home and were bussed to the center daily. Most vocational activities at this center involved light physical work for 5 to 6 hours 5 days a week. Participants without disabilities were recruited from local and university communities through word of mouth, flyers posted on boards, and community organizations. For inclusion, participants without disabilities had to fulfill the following criteria: (1) healthy medical status, (2) nonsmoking condition, (3) sex match with participants with DS, (4) age match with participants with DS, and (5) agreement with the study procedures, confirmed by signature on the written informed consent. Before data collection, each participant was familiarized with the laboratory setting, treadmill protocols, and use of the headgear and face mask. Familiarization sessions were continued until each participant could walk on the treadmill comfortably with the headgear and mouthpiece without handrail support. As in previous studies,¹⁵ participants also were given the opportunity to practice using strength-testing

equipment. Approximately 30 minutes were spent showing the correct use and technique of the 9 different exercises. Each participant performed 2 sets of 8 to 15 repetitions in each exercise. Familiarization sessions were helpful in teaching participants the correct procedures and identifying close approximations of their 12-RM. All participants were adequately familiarized within 1 or 2 sessions.

Study Design

Measurements were obtained at baseline (pre) and after a 12-week combined exercise intervention (post). During the exercise intervention, participants were instructed not to participate in any other form of exercise training. At baseline, participants completed a whole-body composition assessment after a 12-hour overnight fast. Immediately after body composition assessment, participants underwent at rest, submaximal, and maximal exercise testing. Testing was carried out in the laboratory with an environmental temperature of 21°C to 24°C and relative humidity of 44% to 56%. During a second visit (48h after exercise testing), participants underwent 12-RM multiexercise testing. All within-participant sessions were conducted at the same time of day (between 7:00 AM and 11:00 AM) to reduce possible diurnal variation. Participants were asked to refrain from exercise for 24 hours before testing and from caffeine ingestion on testing days. Post measures were conducted approximately 48 hours after the last exercise session.

Body Composition

Body mass was measured using a calibrated digital scale, and height was measured using a stadiometer^a (standing digital scale/height rod attached). BMI was calculated by dividing participants' mass in kilograms by the square of height in meters. The Dubois and Dubois²² formula was used for BSA calculations. Bioelectrical impedance spectroscopy additionally was performed, using a multifrequency bioimpedance meter,^b for measurement of whole-body composition fat mass, fat-free mass, and intracellular and extracellular body water volumes. Participants were asked to empty their bladders before each measurement. For these experiments, a nonconducting bed was used. All metal items were removed from participants to ensure the accuracy of the measurement. Participants lay in the supine position with their arms and legs abducted at a 45° angle. Measurements were carried out after a latency period of 10 minutes to stabilize the organic water compartments before assessments, with each participant lying still. After the skin was cleaned with alcohol, 4 Ag/AgCl electrodes were placed on the dorsal surfaces of the right hand and right foot. Two electrodes were placed on the right wrist, with 1 proximal to the third metacarpophalangeal joint (positive) and the other next to the ulnar head (negative). Two electrodes also were placed on the right ankle, with 1 just proximal to the third metatarsophalangeal joint (positive) and the other between the medial and lateral malleoli (negative). Currents were introduced from the positive leads and travelled throughout the body to the negative leads. Each set of measurements was obtained at 496 frequencies between 4 and 1012kHz. Percentage of body fat then was calculated using the resistance at 50kHz. This single frequency was used to derive fat-free mass by using the Segal et al²³ equation. According to Sardinha et al,²⁴ the accuracy of bioelectrical impedance spectroscopy, cross-validated by using dual x-ray absorptiometry, increases by using the resistance at 50kHz for percentage of body fat calculations (in comparison to standardized use of the manufacturer's equation).

At Rest and Submaximal Exercise Protocol

As in previous studies, participants' $\dot{V}O_2$ at rest was obtained during a 5-minute standing period after a quiet rest of 10 minutes in the seated position.⁸ Cardiorespiratory data were collected while exercising on a motorized treadmill,⁶ and expired gas measurements were made using a portable mixing chamber system,⁴ which was calibrated before each test with a known volume and known gas concentrations. The protocol involved 5 minutes of continuous horizontal walking at a constant speed of 2.5km/h. Subsequently, speed was increased to 4km/h and held constant at 3 different treadmill grades (0%, 2.5%, 5%) for 5 minutes each. Heart rate data were obtained by using a Polar RS 800 R-R recorder.⁶ Submaximal treadmill speeds were selected on the basis of results reported in previous studies.^{25,26} Accordingly, adults with DS preferred walking velocities of approximately 2.5km/h²⁵ and had walking economy similar to adults without disabilities at this specific treadmill workload.²⁶ Additionally, this protocol has been validated for adults with and without DS.^{27,28} The $\dot{V}O_2$ data were displayed as 30-second averages. The mean of the last 3 minutes of the 5-minute rest period was defined as participants' steady-state $\dot{V}O_2$ at rest. For the submaximal exercise test, the mean of the last 3 minutes of each 5-minute walk also was defined as participants' submaximal steady-state $\dot{V}O_2$.²⁹ Additionally, submaximal relative work intensities were determined as percentages of $\dot{V}O_{2peak}$ (FU).

Maximal Protocol

Peak $\dot{V}O_2$ was determined by means of a continuous graded exercise test to volitional exhaustion starting immediately after the last submaximal walk. For this purpose, treadmill grade was increased every 2 minutes by 2.5% until a 12.5% grade was reached. From this point, grade was held constant, whereas speed was increased by 1.6km/h every minute until exhaustion. The test was terminated when the subject reached exhaustion and grasped the hand rails of the treadmill. This protocol has been shown to be both a valid and reliable measure of peak cardiorespiratory fitness in both adults with and without DS.²⁷ The $\dot{V}O_2$ data were displayed in 20-second averages. A valid $\dot{V}O_{2peak}$ was defined as the highest value obtained during the last stage of exercise with an RER greater than 1.0.³⁰

12-RM Protocol

Given that the exercise program in this study was designed for 12-RM and no information is available about the equivalence between RM percentages and numbers of repetitions for adults with DS, muscle strength was determined by using the 12-RM method directly. The 12-RM was measured for 5 exercises using variable-resistance machines^f as follows: (1) leg press, (2) chest press, (3) vertical traction, (4) lower back, and (5) leg extension. Before the 12-RM determination, all participants warmed up for 15 minutes on a treadmill at 50% of their heart rate reserve.³¹ Subsequently, each participant was asked to perform 15 repetitions using a relatively light resistance followed by 30 seconds of recovery. Resistance then was increased, and each participant performed a maximum of 5 sets of 12 repetitions until the 12-RM was attained. The recovery period between sets was exactly 2 minutes, and increments of 2.5 to 5kg were used when each participant approached fatigue. The 12-RM was defined as the maximal load lifted in a full range of motion for a total of 12 repetitions. For most participants, 12-RM was determined within 3 to 4 attempts.

Exercise Training Program

Participants exercised 3 days a week, and each session was conducted with a maximum of 5 participants. Exercise sessions were supervised by an exercise physiologist and 1 assistant. The intervention consisted of 2 days of combined exercise training (Monday and Friday) separated by 1 day of endurance training (Wednesday). Endurance training consisted of 30 minutes of treadmill walking or running at target heart rates compatible to 65% to 85% $\dot{V}O_{2peak}$. Endurance exercise was preceded by a 5-minute warm-up and followed by another 5 minutes of recovery. Warm-up and recovery consisted of treadmill walking at light intensity. During the first 3 weeks, participants exercised for 30 minutes at 65% $\dot{V}O_{2peak}$, then emphasis was placed on reaching and maintaining exercise intensity of approximately 85% $\dot{V}O_{2peak}$ for 30 minutes. Heart rate watch monitors (Vantage Night Vision[®]) were programmed for each participant (upper and lower training heart rate) to ensure that they were exercising in the appropriate target heart rate zone. Participants were given the opportunity to select between walking and running gaits as long as they exercised continuously within the prescribed heart rate zone. Although participants with DS preferred to exercise by using graded treadmill walking, those without disabilities generally choose running at 0% grade. Each staff member was responsible for 1 to 3 participants to encourage them to sustain a treadmill workload compatible with a heart rate closer to the upper limit of the training zone.

Resistance training consisted of 2 rotations in a circuit of 9 exercises with less than 30 seconds of rest between them. Participants trained on the same equipment used for the 12-RM assessments, and each session included the following dynamic exercises: leg press, chest press, vertical traction, shoulder press, lower back, leg extension, biceps curl, and triceps push-down. Exercise stations were prescribed for 12-RM and organized in alternate agonist/antagonist interplay to avoid the early onset of local/regional fatigue. Additionally, participants performed 1 set of 15 repetitions of abdominal curls in each rotation. When participants were able to complete 14 repetitions for 2 consecutive sessions with the proper lifting technique (ie, proper biomechanical motion; avoidance of the Valsalva maneuver, which involves holding the breath), the load was increased by 10% of their 12-RM.

Statistical Analysis

Descriptive statistics were calculated for all variables. Before comparing groups, data were tested for normality and homoscedasticity by using Kolmogorov-Smirnov and Levene tests, respectively. A repeated-measures ANOVA was used to evaluate effects of the training program on participants' body composition, submaximal and peak exercise capacity, and muscle strength. When a significant effect was detected at a significance level of P less than .05, t tests were used for post hoc comparisons. Adjustment for multiple comparisons was made by using Bonferroni correction. Because previous studies provided no definite explanation for improvements seen in work capacity of adults with DS after training, we repeated the ANOVAs conducted on graded exercise test time by using the training-induced changes in walking economy and $\dot{V}O_{2peak}$ as covariates. This analysis was performed separately in participants with and without DS. All data are reported as mean $\pm$ SD unless otherwise specified. Statistical significance was set at P less than .05. All data analysis was carried out using Statistical Package for the Social Sciences.⁸

Table 1: Body Composition and Cardiorespiratory Data at Rest for Participants With and Without DS at Pre- and Posttraining Conditions

Variables	DS (n=13)		Participants Without Disabilities (n=12)	
	Pretraining	Posttraining	Pretraining	Posttraining
Body composition				
Body mass (kg)	68.6±9.2	67.7±9.2*	81.2±17.1	81.4±16.3
BSA (m ²)	1.7±0.1	1.7±0.1*	1.9±0.2	1.9±0.2
BMI (kg/m ²)	29.3±3.7	28.9±3.6	26.6±4.5	26.6±4.2
Fat mass (kg)	19.5±4.0	19.1±4.1	21.7±8.5	21.8±7.7
Fat-free mass (kg)	48.1±6.9	47.8±7.0*	59.4±9.2	59.5±9.2
Relative fat mass (%)	28.4±4.3	28.4±4.4	25.6±5.3	26.2±4.5
Cardiorespiratory data at rest				
$\dot{V}O_2$ (mL·kg ⁻¹ ·min ⁻¹)	4.2±0.8	3.9±0.5	4.0±0.9	3.9±0.8
BSA $\dot{V}e$ (L·min ⁻¹ ·m ⁻²)	4.0±0.6	4.0±0.7	4.5±0.5	4.5±0.9
RER	0.88±0.09	0.80±0.06	0.85±0.06	0.85±0.09
Heart rate (beats/min)	69.6±12.2	67.8±12.3	70.6±16.0	66.1±9.0

Values are mean ± SD.

Abbreviation: BSA $\dot{V}e$, BSA-adjusted minute ventilation.

*Between-group differences at pre- and posttraining periods ($P<.05$).

RESULTS

No differences were observed between groups for age (DS, 36.5±5.5y; participants without disabilities, 38.7±8.3y). Participants with DS were shorter (DS, 152.9±7.9cm; participants without disabilities, 174.3±6.1cm) and presented lower body mass than participants without disabilities at pre- and posttraining periods ($P<.05$) (table 1). BSA also was lower for participants with DS ($P<.05$). In contrast, both groups showed similar values for BMI, absolute fat mass, and relative fat mass at both periods. Nevertheless, participants with DS had lower fat-free mass than participants without disabilities before and after training ($P<.05$). As listed in table 1, the exercise program had no significant effect on body composition. Of relevance, there were no withdrawals from the study and no adverse events for the intervention were noted.

Submaximal Exercise

There were no significant differences between groups at rest before or after training (see table 1). However, participants with DS showed higher overall $\dot{V}O_2$ (lower exercise economy) than participants without disabilities during submaximal exercise (group main effect, $F=23.7$; $P<.05$) (fig 1A and B). As listed in table 2, there was an overall decrease in submaximal $\dot{V}O_2$ in both groups after training (time main effect, $F=30.5$; $P<.05$). However, although improvements in participants with DS were extensive to all submaximal workloads performed at 4km/h, those of participants without disabilities reached significance at only 0% and 2.5% treadmill grades (time-by-group interaction, $F=5.7$; $P<.05$). Training had no effects on submaximal $\dot{V}O_2$ of either group at a walking speed of 2.5km/h.

As listed in table 2, participants with DS relied on higher FU of $\dot{V}O_{2peak}$ than participants without disabilities at all submaximal workloads during both the pre- and posttraining periods (group main effect, $F=50.5$; $P<.05$). Nevertheless, after training, both groups showed lower FU of their $\dot{V}O_{2peak}$ at each treadmill workload (time main effect, $F=35.7$; $P<.05$). However, compared with participants without disabilities, those with DS showed a greater decrease in FU of $\dot{V}O_{2peak}$ during the horizontal treadmill walk at 4km/h (time-by-group interaction, $F=6.3$; $P<.05$).

Pretraining, participants with DS had higher BSA-adjusted minute ventilation than those without disabilities at all submaximal workloads ($P<.05$) except the 2.5-km/h treadmill walking speed (see table 2). However, whereas training induced no significant changes in the nondisabled group, partic-

ipants with DS decreased their BSA-adjusted minute ventilation during horizontal and graded (2.5% and 5%) treadmill walking at 4km/h ($P<.05$). Furthermore, differences between groups at baseline were no longer significant after training.

Compared with participants without disabilities, those with DS showed higher RERs during exercise at 4km/h (horizontal and graded; $P<.05$) (fig 1C). With the exception of 2.5-km/h treadmill walking speed, training resulted in significant RER reductions at all submaximal workloads; however, this occurred in only participants with DS (time-by-group interaction, $F=8.1$; $P<.05$) (see table 2). Because of these improvements, the pretraining group differences seen during exercise at 4km/h were no longer significant after training (fig 1D).

Participants with DS exercised at higher heart rates than controls while walking at a 5% treadmill grade (see table 2) ($P<.05$). Conversely, the magnitude of increase in heart rate across submaximal workloads was similar between groups before training. After training, nondisabled participants showed a more attenuated chronotropic response to submaximal exercise than participants with DS. This was manifested by a lower increase in heart rate during the transition between walking speeds (2.5–4km/h) and grades (0%–2.5%; $P<.05$).

Peak Exercise

Table 3 lists peak cardiorespiratory data for participants with and without DS at pre- and posttraining. Compared with participants without disabilities, those with DS showed lower peak values for $\dot{V}O_2$, BSA-adjusted minute ventilation, RER, heart rate, and graded exercise test time at both times. However, training resulted in significant improvements in peak values for $\dot{V}O_2$, BSA-adjusted minute ventilation, and graded exercise test time in participants with and without DS ($P<.05$). Importantly, there were no differences in the magnitude of these changes between groups (fig 2). Peak heart rate or peak RER did not change with training (see table 3).

We also repeated ANOVAs conducted on graded exercise test time to explore possible relationships between increased work capacity and improvements in physiologic function resulting from training. We found that after controlling for training-induced improvements in submaximal $\dot{V}O_2$ and $\dot{V}O_{2peak}$, there were no significant differences between pre- and posttraining graded exercise test times in either group (DS, $F=2.2$; participants without disabilities, $F=3.8$; $P>.05$). Additionally, for participants with

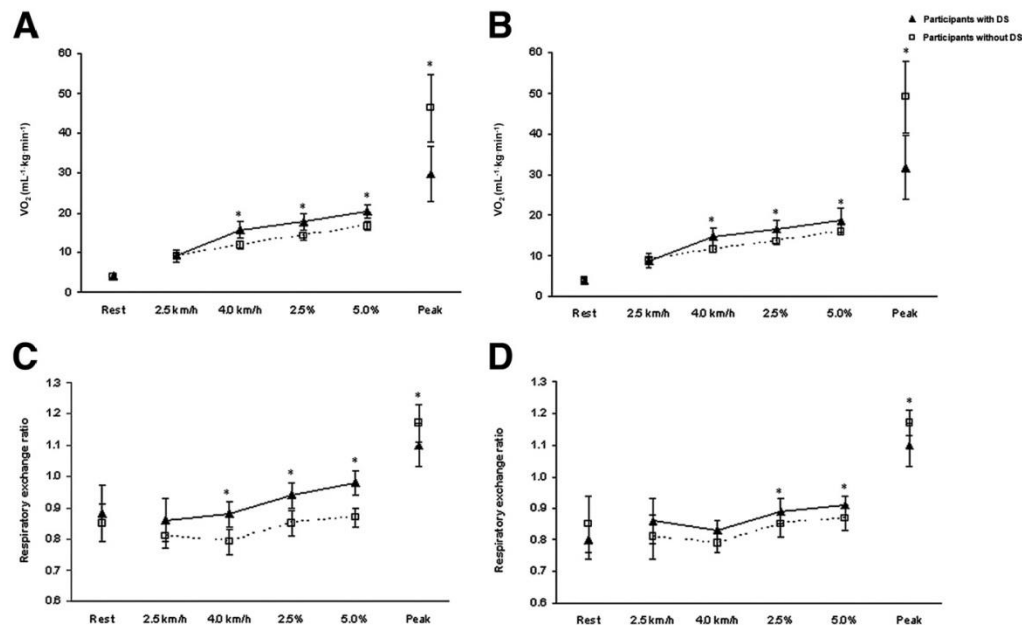


Fig 1. The VO_2 and RER of participants with and without DS at rest, during 4 different submaximal treadmill workloads (2.5 km/h, 0% grade; 4 km/h, 0% grade; 4 km/h, 2.5% grade; 4 km/h, 5% grade), and at peak exercise. (A) Pretraining VO_2 , (B) posttraining VO_2 , (C) pretraining RER, and (D) posttraining RER. *Between-group differences ($P < .05$).

DS, similar findings were obtained after controlling exclusively for gains in walking economy ($F=2.4$; $P>.05$).

Muscle Strength

Participants with DS showed lower muscle strength than participants without disabilities in all dynamic exercises both pre- and posttraining (group main effect, $F=15.3$; $P<.05$). As listed in table 3, training was effective in eliciting generalized improvements for 12-RM in both groups ($P<.05$). The magnitude of these improvements was similar between participants with and without DS.

DISCUSSION

Overall, our results showed that adults with DS improved their physical fitness in a magnitude similar to adults without disabilities after 12 weeks of combined exercise. Additionally, to our knowledge, this was the first study to report significant improvements in walking economy after an exercise intervention in persons with DS (6.6%–10.4%). Given their increased oxygen cost of locomotion,^{7,8} these improvements may have a large impact on their ability to perform daily activities. Noteworthy, we also found that gains in work capacity resulting from exercise training were dependent on those in walking economy and $\text{VO}_{2\text{peak}}$. Importantly, all these improvements were similar between participants with and without DS.

Maximal Exercise

Our results agree with previous reports showing that compared with nondisabled participants, adults with DS had dimin-

ished work performance, decreased $\text{VO}_{2\text{peak}}$, and chronotropic incompetence.^{2,3} Despite the ubiquitous nature of these findings, only 5 previous training studies were conducted in adolescents and adults with DS.^{12–16} In the present study, we found that a 12-week combined exercise program elicited significant improvements in $\text{VO}_{2\text{peak}}$ of adults with DS. Of relevance, there were no differences between pre- and posttraining peak values for RER or heart rate. This suggests that participants produced valid peak efforts at both times. Moreover, because there were no significant changes in body composition or body mass after training, gains in peak aerobic capacity did not depend on decreases in participants' body mass or increases in fat-free mass. Our results agree with those of Rimmer et al,¹⁵ who also found significant increases in $\text{VO}_{2\text{peak}}$ after 12 weeks of combined exercise training. Therefore, a combined exercise prescription constitutes an effective stimulus for increasing peak aerobic capacity of adults with DS. Importantly, participants with DS showed a magnitude of improvement similar to participants without disabilities for peak VO_2 (DS, 6%; participants without disabilities, 6.9%), minute ventilation (DS, 5.0%; participants without disabilities, 8.2%), and graded exercise test time (DS, 19.1%; participants without disabilities, 15.2%). Our findings suggest that adults with DS respond to combined exercise training as participants without disabilities, thus supporting that conventional exercise prescription guidelines, such as those recommended by the American College of Sports Medicine,³² are well suited for this population. We found that increases in $\text{VO}_{2\text{peak}}$ were paired by gains in peak minute ventilation in participants with and without DS. This

Table 2: Submaximal Cardiorespiratory Data for Participants With and Without DS at Pre- and Posttraining Conditions

Variables	DS (n=13)		Participants Without Disabilities (n=12)	
	Pretraining	Posttraining	Pretraining	Posttraining
$\dot{V}O_2$ (mL $\cdot$ kg $\cdot$ min $^{-1}$)				
2.5km/h	9.3 $\pm$ 1.5	8.8 $\pm$ 1.8	9.2 $\pm$ 0.7	8.9 $\pm$ 0.6
4.0km/h	15.6 $\pm$ 2.1	14.6 $\pm$ 2.2* [†]	12.0 $\pm$ 0.9	11.5 $\pm$ 0.8*
2.5%	17.9 $\pm$ 2.1	16.6 $\pm$ 2.2* [†]	14.2 $\pm$ 1.0	13.6 $\pm$ 0.8*
5%	20.4 $\pm$ 1.7	18.7 $\pm$ 2.8* [†]	16.7 $\pm$ 1.1	16.3 $\pm$ 0.8
FU $\dot{V}O_{2peak}$ (%)				
2.5km/h	32.6 $\pm$ 9.1	29.4 $\pm$ 10.3 [†]	20.6 $\pm$ 4.0	18.5 $\pm$ 3.2*
4.0km/h	54.7 $\pm$ 12.7	48.1 $\pm$ 10.5* [†]	26.8 $\pm$ 4.9	24.0 $\pm$ 3.9*
2.5%	62.9 $\pm$ 14.8	55.2 $\pm$ 11.9* [†]	31.8 $\pm$ 6.1	28.5 $\pm$ 4.7*
5%	71.4 $\pm$ 15.6	61.1 $\pm$ 10.6* [†]	37.4 $\pm$ 7.3	34.1 $\pm$ 5.9*
BSA $\dot{V}e$ (L $\cdot$ min $^{-1}$ $\cdot$ m 2)				
2.5km/h	10.0 $\pm$ 1.6	9.6 $\pm$ 1.2	9.3 $\pm$ 1.1	9.1 $\pm$ 1.0
4.0km/h	14.5 $\pm$ 2.8	12.9 $\pm$ 2.3* [†]	11.3 $\pm$ 1.2	10.9 $\pm$ 1.2
2.5%	17.2 $\pm$ 3.1	15.5 $\pm$ 2.6* [†]	13.8 $\pm$ 1.3	13.2 $\pm$ 1.5
5%	20.5 $\pm$ 3.2	17.7 $\pm$ 3.2 [†]	16.4 $\pm$ 1.6	15.9 $\pm$ 1.8
RER				
2.5km/h	0.86 $\pm$ 0.07	0.86 $\pm$ 0.07	0.81 $\pm$ 0.04	0.81 $\pm$ 0.07
4.0km/h	0.88 $\pm$ 0.04	0.83 $\pm$ 0.03* [†]	0.79 $\pm$ 0.04	0.79 $\pm$ 0.04
2.5%	0.94 $\pm$ 0.04	0.89 $\pm$ 0.04* [†]	0.85 $\pm$ 0.04	0.85 $\pm$ 0.03
5%	0.98 $\pm$ 0.04	0.91 $\pm$ 0.03* [†]	0.87 $\pm$ 0.03	0.87 $\pm$ 0.03
Heart rate (beats/min)				
2.5km/h	88.2 $\pm$ 13.2	81.6 $\pm$ 10.2	77.8 $\pm$ 11.3	77.5 $\pm$ 9.2
4.0km/h	100.5 $\pm$ 12.4	96.5 $\pm$ 11.2	88.1 $\pm$ 15.8	84.1 $\pm$ 11.2
2.5%	109.8 $\pm$ 13.6	106.5 $\pm$ 10.7 [‡]	95.0 $\pm$ 17.6	90.9 $\pm$ 10.6
5%	121.2 $\pm$ 13.8	116.9 $\pm$ 10.5 [†]	103.0 $\pm$ 18.6	97.9 $\pm$ 11.2

NOTE. Values are mean $\pm$ SD.Abbreviation: BSA $\dot{V}e$, BSA-adjusted minute ventilation.*Within-group differences after training ($P < .05$).[†]Between-group differences at pre- and posttraining ($P < .05$).[‡]Between-group differences at pretraining ($P < .05$).[§]Between-group differences at posttraining ($P < .05$).

agrees with the findings of Boutellier³³ and Johnson et al,³⁴ thus indicating that improvements in $\dot{V}O_{2peak}$ were associated with higher ventilatory ability after training. As previously reported, training enhances the ability to sustain high levels of minute ventilation because of a coupling between improved ventilatory muscle endurance and increases in inspiratory mus-

cle capacity to generate force and sustain a given level of inspiratory pressure.³⁵

Submaximal Exercise

As in previous studies, participants with DS showed poorer walking economy than participants without disabilities at all

Table 3: Peak Exercise and Muscle Strength Data for Participants With and Without DS at Pre- and Posttraining Periods

Variables	DS (n=13)		Participants Without Disabilities (n=12)	
	Pretraining	Posttraining	Pretraining	Posttraining
Peak exercise				
$\dot{V}O_2$ (mL $\cdot$ kg $\cdot$ min $^{-1}$)	29.8 $\pm$ 7.1	31.7 $\pm$ 7.9* [†]	46.3 $\pm$ 9.6	49.1 $\pm$ 8.5*
BSA $\dot{V}e$ (L $\cdot$ min $^{-1}$ $\cdot$ m 2)	37.8 $\pm$ 11.1	39.9 $\pm$ 12.2* [†]	61.0 $\pm$ 10.7	65.4 $\pm$ 10.0*
RER	1.10 $\pm$ 0.07	1.10 $\pm$ 0.07 [†]	1.17 $\pm$ 0.06	1.17 $\pm$ 0.04
Heart rate (beats/min)	166.8 $\pm$ 19.9	167.6 $\pm$ 19.1 [†]	183.0 $\pm$ 10.9	182.4 $\pm$ 9.5
GXT time (min)	4.8 $\pm$ 0.6	5.4 $\pm$ 0.8* [†]	6.3 $\pm$ 0.9	6.9 $\pm$ 0.8*
Muscle strength				
Leg press (kg)	94.1 $\pm$ 47.9	110.2 $\pm$ 52.6* [†]	149.6 $\pm$ 56.6	171.3 $\pm$ 56.5*
Vertical traction (kg)	31.5 $\pm$ 13.1	39.2 $\pm$ 14.1* [†]	51.5 $\pm$ 12.2	59.4 $\pm$ 15.3*
Chest press (kg)	27.5 $\pm$ 9.5	35.3 $\pm$ 12.2* [†]	44.4 $\pm$ 15.5	51.3 $\pm$ 21.0*
Lower back (kg)	31.3 $\pm$ 7.3	35.6 $\pm$ 7.4* [†]	44.8 $\pm$ 18.4	51.9 $\pm$ 19.3*
Leg extension (kg)	22.2 $\pm$ 7.0	30.1 $\pm$ 10.3* [†]	43.5 $\pm$ 17.8	52.7 $\pm$ 17.6*

NOTE. Values are mean $\pm$ SD.Abbreviations: BSA $\dot{V}e$, BSA-adjusted minute ventilation; GXT, graded exercise test.*Within-group differences after training ($P < .05$).[†]Between-group differences at pre- and posttraining ($P < .05$).

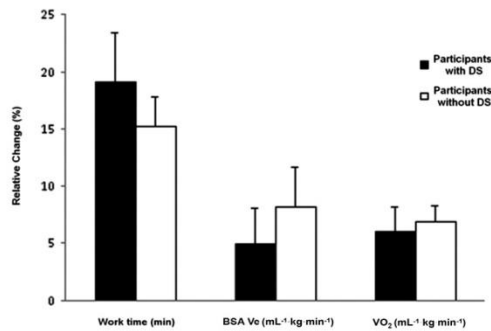


Fig 2. Relative change in work time, BSA-adjusted minute ventilation (BSA $\dot{V}_e$) and $\dot{V}_{O_2}$ peak in participants with and without DS after training.

treadmill speeds other than their preferred walking speed (2.5km/h).⁸ Nevertheless, we found that combined exercise training was an effective intervention for improving walking economy of adults with DS, and this is novel. Given that participants without disabilities also showed lower submaximal $\dot{V}_{O_2}$ during steady-state exercise after training, improvements in walking economy were not exclusive to adults with DS. However, according to our results, the mechanisms underlying these findings may be different between groups. Although these improvements in participants with DS were paralleled by a decrease in submaximal minute ventilation, this was not the case for participants without disabilities. Therefore, persons with DS showed greater walking economy after training, and this apparently was associated with decreases in ventilatory demands during submaximal exercise. This agreed with previous studies showing that lower minute ventilation decreased the oxygen cost of locomotion.³⁶ Because training in these participants also contributed to a generalized decrease in RERs during submaximal workloads, it is possible that the decrease in minute ventilation may have resulted from lower levels of carbon dioxide produced during exercise. Our results corroborate previous findings showing a considerable decrease in submaximal RERs in persons with DS after exercise training.¹⁶ Conversely, in participants without disabilities, these improvements were not paired by such findings. Rossiter et al³⁷ showed that activation of pyruvate dehydrogenase by dichloroacetate determined lower oxygen cost during exercise because of more efficient coupling between the amounts of ATP synthesized per mole of oxygen used within the muscle.³⁸ Therefore, improvements in walking economy, such as those seen in adults without disabilities after training, may be related to increases in the functionality of specific skeletal muscle mitochondrial enzymes. Importantly, this does not necessarily implicate changes in the nature of the substrate being oxidized for ATP synthesis.

In contrast to participants without disabilities, those with DS showed a training effect on steady-state $\dot{V}_{O_2}$ while walking at a 5% treadmill grade. This may have been a function of how they trained because the participants with DS included in this study preferred to exercise (within their training zones) using graded treadmill walking. Conversely, participants without disabilities generally choose running at 0% treadmill grade. Considering that the metabolic adaptations that occur within the skeletal muscle are specific to the training stimulus,³⁹ the lack of improvement in adults without disabilities at a steeper tread-

mill grade may be related to the form of exercise selected by these participants during the training sessions. Nevertheless, both groups exercised at lower FU of their $\dot{V}_{O_2}$ peak after training. Although these training-induced decreases in relative intensity resulted from a combination of improved walking economy and increased $\dot{V}_{O_2}$ peak during most submaximal workloads, this was not the case for the 2.5-km/h treadmill walking speed in either group or during the 5% graded walk for participants without disabilities. Under these conditions, the decrease in FU was simply caused by the gains seen in participants' $\dot{V}_{O_2}$ peak after training.

Relationships Between Work Capacity and Physiologic Adaptations

Although this is the first evidence of improvements in walking economy of adults with DS, all previous studies of persons with DS had observed significant gains in work capacity after training.¹²⁻¹⁶ Interestingly, as reported by Millar et al¹² and Varela et al,¹³ this occurred without concomitant increases in $\dot{V}_{O_2}$ peak. As reviewed by Saunders et al⁴⁰ and McCann and Higginson,⁴¹ several studies supported that improvements in exercise economy can lead to gains in peak work capacity, even without significant changes in $\dot{V}_{O_2}$ peak. Therefore, we hypothesized that changes seen in the work capacity of persons with DS after training might result from a combination between improvements in exercise economy and $\dot{V}_{O_2}$ peak. After repeating our statistical analyses on graded exercise test time, while controlling for training-induced changes in walking economy and $\dot{V}_{O_2}$ peak, we found that differences in work capacity between pre- and posttraining periods were no longer significant in either group. This indicates that enhancements in work capacity, such as those obtained in both groups after training, were dependent largely on a combination between improvements in walking economy and $\dot{V}_{O_2}$ peak. Consequently, although not measured in their studies, the gains in work capacity reported by Millar¹² and Varela¹³ most likely were caused by improved exercise economy after training.

Muscle Strength

We found that both groups showed generalized improvements in muscle strength after training. Noteworthy, as for peak endurance capacity, the magnitude of gains in muscle strength were not different between participants with and without DS (DS, 15.3%–35.9%; participants without disabilities, 15.8%–30.5%). According to recent findings, knee extensor strength predicts time performance of daily tasks in adults with DS.⁶ Participants with DS included in the present study improved their leg extension 12-RM by approximately 35%. Therefore, it may be speculated that training represented a positive stimulus to enhance the ability of these persons to perform common tasks of daily living. Additionally, increased leg-extensor strength leads to a decrease in relative load placed on the muscle during submaximal exercise.⁴² Because persons with DS are documented to adjust their gait pattern to favor greater gait stability,^{25,43-46} the decreased relative load could have improved their stability during walking, thereby leading to a decreased demand for oxygen when walking.

Study Limitations

There are several limitations to this study. First, DS is a genetic disorder with diverse physiologic consequences. However, physical work capacity and heart rate responses to peak exercise are remarkably consistent in the literature, and our present data are similar to those previously reported. Second, peak treadmill exercise is effort dependent; thus, it is possible

that participants with DS may have produced lower effort than participants without disabilities. We used validated protocols and accepted criteria for peak effort during treadmill testing. Therefore, we do not believe that our data were influenced substantially by lack of effort in participants from either group. Third, because 12 RM represents a complex combination of muscle endurance and muscle strength, we are unable to determine the exact origin of the improvements induced by training in either group. Fourth, our experimental design did not include nonexercising control groups; therefore, the extent to which these findings are caused by the effects of the combined exercise program rather than to series effects is not known. Finally, the lack of blinded assessors to collect data at pre- and posttraining periods also may correspond to a limitation of the present study.

CONCLUSIONS

We found that adults with DS showed similar gains in peak exercise capacity and muscle strength, as participants without disabilities, after 12 weeks of combined exercise training. Furthermore, these data provide preliminary evidence that combined exercise training may represent an effective intervention strategy to improve their decreased walking economy. Importantly, the present findings suggest that enhanced work capacity in adults with DS after training depends on a combination between improved exercise economy and higher $\dot{V}O_{2\text{peak}}$, and this is similar to that observed in participants without disabilities.

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ORIGINAL ARTICLE

Effects of a Community-Based Progressive Resistance Training Program on Muscle Performance and Physical Function in Adults With Down Syndrome: A Randomized Controlled Trial

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ABSTRACT. Shields N, Taylor NF, Dodd KY. Effects of a community-based progressive resistance training program on muscle performance and physical function in adults with Down syndrome: a randomized controlled trial. *Arch Phys Med Rehabil* 2008;89:1215-20.

Objective: To determine whether progressive resistance training improves muscle strength, muscle endurance, and physical function in adults with Down syndrome.

Design: Single-blind randomized controlled trial.

Setting: General community.

Participants: Adults (N=20) with Down syndrome (13 men, 7 women; mean age, 26.8±7.8y) were randomly assigned through a concealed allocation block randomized method to either an intervention group (n=9) or a control group (n=11).

Intervention: The intervention was a supervised, group progressive resistance training program, consisting of 6 exercises using weight machines performed twice a week for 10 weeks. Participants completed 2 to 3 sets of between 10 to 12 repetitions of each exercise until they reached fatigue. The control group continued with their usual activities.

Main Outcome Measures: The outcomes measured by blinded assessors were muscle strength (1-repetition maximum [1-RM]), muscle endurance (number of repetitions at 50% of 1-RM) for chest press and leg press, timed stairs test, and the grocery shelving task.

Results: The intervention group showed significant improvement in upper-limb muscle endurance compared with the control group (mean difference in the number of repetitions of the chest press at 50% of 1-RM was 16.7, 95% confidence interval, [CI] 7.1–26.2); and a trend toward an improvement in upper-limb muscle strength (mean difference in chest press 1-RM, 8.6kg; 95% CI, –1.3 to 18.5kg) and in upper-limb function (mean difference in grocery shelving task, –20.3s; 95% CI, –45.7 to 5.2s). There were no significant differences between the groups for lower-limb muscle performance or physical function measures. No major adverse events for the intervention were noted.

Conclusions: Progressive resistance training is a safe and feasible fitness option that can improve upper-limb muscle endurance in adults with Down syndrome (ACTR identifier ACTRN 012606000515594.)

Key Words: Down syndrome; Exercise; Randomized controlled trial; Rehabilitation.

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PEOPLE WITH DS HAVE REDUCED muscle strength and muscular endurance compared with their peers without disability and also compared with their peers with an intellectual disability but without DS.¹⁻³ Muscle weakness is associated with decreased cardiovascular fitness⁴ and an increased incidence of osteoporosis in people with DS.⁵ It can also impact the ability of people with DS to perform everyday activities, such as walking, maintaining balance while standing, and rising from a chair.⁶ Further, because their workplace activities typically emphasize physical rather than cognitive skills, decreased strength can negatively impact the vocational and social development of adults with DS in the workforce.^{7,8}

People with a range of disabilities have the capacity to improve muscle strength with progressive resistance training.^{9,10} However, only 3 trials are known to have investigated the effects of this type of training program in people with DS.¹¹⁻¹³ Two of these trials included progressive resistance training^{11,12} and 1 study used a combined strength training and aerobic program.¹³ Each of these trials found improved upper-¹¹⁻¹³ and lower-limb muscle strength with training^{12,13} but none of the trials reported the effects of the programs on muscle endurance or functional activities. These trials were also limited because none employed blinded assessors to collect the data and 2 studies^{11,12} did not include a control group in their design. Because no RCT has been conducted investigating the effectiveness of a stand-alone progressive resistance training program, it is not known to what extent the reported effects of progressive resistance training in people with DS are due to the strength training intervention rather than due to series effects.

The aim of this trial therefore was to determine the effects of a community gymnasium-based progressive resistance training program on adults with DS. The specific objectives were to conduct an RCT to determine if a progressive resistance training program for adults with DS can lead to increased muscle strength and endurance, and, to improved physical function in this population. It was hypothesized that the adults with DS in the strength training program would have greater improvement in muscle strength, muscle endurance, and improved physical function compared with the control group.

List of Abbreviations

ACSM	American College of Sports Medicine
CI	confidence interval
DS	Down syndrome
1-RM	1 repetition maximum
RCT	randomized controlled trial

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METHODS

Research Design

We conducted a repeated-measures RCT. Adults with DS were randomly allocated to either an intervention group that received 10 weeks of progressive resistance training or a control group that continued with their usual activities. Both groups were assessed at baseline and after the intervention phase of the study. The trial received ethics approval from the university ethics committee, and all participants and their carers gave written informed consent to take part in the trial.

Participants

We recruited adults with DS through 2 disability agencies (1 rural, 1 metropolitan) that provide supported employment and day activity programs for adults with intellectual disabilities. The agencies mailed a flyer promoting the trial to a total of 46 families and those who were interested in taking part contacted the researchers directly. Participants were included if they were aged 18 years or more, had the ability to follow simple verbal instructions in English, and were fit and well enough to participate in a progressive resistance training program. The latter was determined by asking the carer of each participant to complete a copy of the 7-item Physical Activity Readiness Questionnaire.¹⁴ The level of intellectual disability of each of the participants (described as mild, moderate, or severe as perceived by their parent or carer) was also documented. The exclusion criterion was participation in a strength training program in the 6 months prior to the start of the study. Based on a power analysis of the training effects on lower-limb muscle strength found in people with DS in a previous study ($d=1.26$),¹² it was calculated that 10 subjects would be needed in each group to obtain power of 80%.

Randomization

Participants were randomly allocated to either the intervention or control group using a concealed allocation, block randomization method that ensured approximately equal numbers in each group with the relatively small sample.¹⁵ We considered participants in blocks of 4, with 6 ways or permutations in which to get 2 intervention and 2 control participants in each block. The order of the blocks was generated from a random number table and assignments sealed in sequentially numbered opaque envelopes. Only after the recruiter determined if a person was eligible for the study and they had agreed to participate was random assignment made. Participants were assigned to their allocation by a physiotherapist not involved in the study after the baseline measures were taken.

Intervention

Participants in the intervention group completed a 10-week progressive resistance training program. Training was completed twice a week at a community gymnasium and followed the principles of progressive resistance training as recommended by the ACSM.¹⁶ The program consisted of 6 exercises using weight machines: 3 for the upper limbs (shoulder press, seated chest press, seated row) and 3 for the lower limbs (seated leg press, knee extension, seated calf raise). These exercises formed the basis of the training program but could be modified to suit the needs of the individual. For example, if a participant found it difficult to do the seated calf raise exercise, the trainer could try modifying the exercise as a standing calf raise exercise. Participants completed 2 to 3 sets of between 10 to 12 repetitions of each exercise until they reached fatigue. A 2-minute rest period was given between each set to allow for

recovery, and the resistance was increased when 2 sets of 12 repetitions of an exercise could be completed.¹⁶ A log book for each participant that detailed each exercise, the weight lifted, the number of repetitions, and number of sets was filled at each session by the exercise trainer. Participants completed the program as a group, supervised by 2 accredited fitness trainers. Each trainer supervised the training of a subgroup of 2 to 3 participants. Exercising in a small subgroup allowed for a close level of supervision.

Participants in the control group continued with their typical daily activities, which included employment, leisure, and sporting activities, but did not include a progressive resistance training program. For ethical reasons, after the 10-week assessment, participants in the control group were invited to complete the strengthening program, but no further follow-up measurements were conducted.

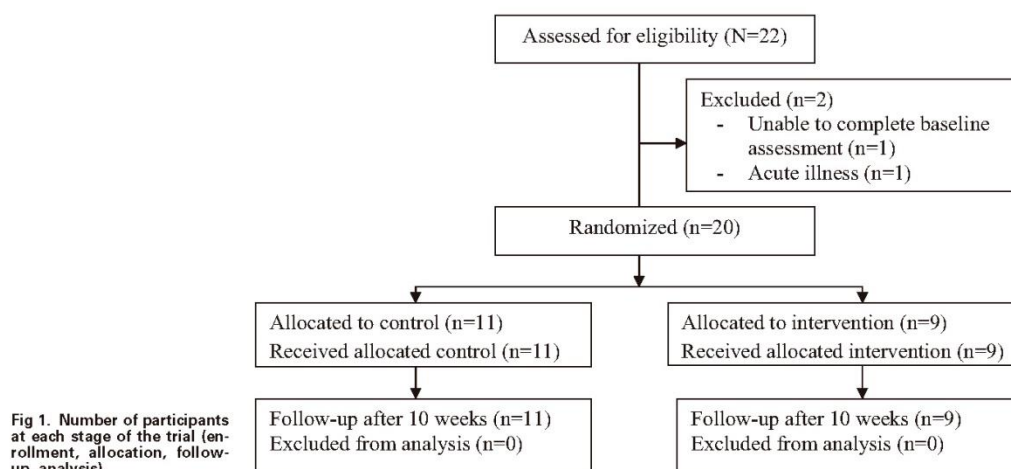
Outcome Measurements

We assessed all participants at baseline (week 0) and immediately after the intervention period (week 10) at the recreation center where the intervention took place. The outcome measurements were taken by assessors who were blind to group allocation and who had no involvement in the recruitment, the randomization, or the training of participants. There were 2 assessors: 1 assessor completed the muscle performance tests and the second assessor completed the physical function tests. Assessors received training on how to administer the outcome measures.

Muscle performance was assessed using tests for maximal force generation (1-RM) and muscle endurance. Maximal muscle force generation was tested by establishing the amount of weight each participant could lift in a single seated chest press and seated leg press (1-RM). A single 1-RM chest press and leg press have been measured with high levels of retest reliability ($r>.89$) and no systematic change when measured over 3 weeks in adults with neurologic impairment.¹⁷ Muscle endurance was measured by counting the number of repetitions that could be completed when the weight on the seated chest press and seated leg press was lowered to 50% of 1-RM. The baseline weight that was lifted was used for the 10-week measurement.¹⁸ There is evidence of construct validity for this measure because hypothesized changes were detected in a group of adults with neurologic impairment.¹⁷

Physical function was measured using 2 outcomes measures; the timed stairs test and the grocery shelving task. For the timed up and down stairs test, participants stood at the bottom of a flight of stairs and were asked to ascend and descend the steps as quickly and as safely as possible. Participants were allowed to choose any method of traversing the stairs including alternating steps, running up the stairs, or skipping steps. There were 2 handrails available on the stairs and participants were allowed to use these. The participants were given the cues, ready and go, and the time taken to go up the stairs, turn around, come all the way down until both feet landed at the foot of the stairs was recorded in seconds using a stopwatch. The test was repeated twice with the fastest time used in the analysis.¹⁹ The test has been measured reliably ($r=.89$) in a population of adults with multiple sclerosis.²⁰

We used the grocery shelving task²¹⁻²³ to measure upper-body functional activity. For this test, participants were asked to stand up from a chair and carry 2 grocery bags to a bench 2m away. Each grocery bag contained 10 items; each item weighed 410g (total weight of each grocery bag, 4.1kg). The participants then took the items out of the bag and stacked them onto a shelf at shoulder height. Participants were asked to complete the task as quickly as possible and the time taken



to complete the test was measured. All the participants were given 1 practice trial at each assessment before they completed 2 timed tests, the average of which was used in the analysis. The grocery shelving task has shown high retest reliability (intraclass correlation coefficient, .98) when tested over 6 weeks in a group of adults with respiratory disability,²¹ but has not previously been applied to adults with intellectual disability.

Adverse events that occurred during training (including minor events such as delayed onset muscle soreness) were systematically recorded by the fitness trainers on the participant's exercise log book. At the start and at the end of each exercise session the trainer asked each participant if they had experienced any injuries or any other problems.

Data Analysis

Data were analyzed using SPSS statistical software^a to determine if there were any significant baseline demographic (sex, age, weight) differences between the intervention and control groups using the independent *t* test and Fisher exact probability test, as appropriate. Outcomes were analyzed using analysis of covariance on the change scores with the baseline measure of that variable used as the covariate.²⁴ Where baseline variables were significantly different, they too were entered as covariates. The mean difference within each group and the mean difference between the groups and the 95% CIs of the mean differences were also calculated. Effect sizes and 95% CIs were also calculated for the change scores. To avoid bias and to maximize the randomization process, we used intention-to-treat analysis. Where data were missing, the carry forward technique was used, which assumes that missing data remain constant.²⁵

RESULTS

Flow of the Participants Through the Trial

Twenty adults (13 men, 7 women) with DS volunteered to take part in the study. Participants ranged in age from 20 to 49 years, with a mean age $\pm$ SD of 26.8 ± 7.8 years. The mean height of the group was 155.1 ± 9.3 cm (range, 134–169 cm) and

the mean weight was 68.9 ± 13.3 kg (range, 51.8–102.0 kg). Nine participants were randomly allocated to the intervention group and 11 participants to the control group and their progress through the trial is shown in figure 1. The demographic details of the participants for each group are displayed in table 1 and as the table shows, the only significant difference at baseline was that the intervention group weighed more than the control group. Eight of the 20 participants were employed at least 1 day a week performing manual type work that required them to pack boxes of confectionery, sorting and cutting clothing, and assembling automotive parts.

Compliance With the Trial Method

There were no withdrawals from the study. Participants attended 167 (92.8%) of 180 scheduled training sessions. Missed sessions of training were due to illness unrelated to the training program or to vacation time. None of the sessions were missed due to soreness or injury due to the training program.

Table 1: Demographic Data for Intervention and Control Groups

Characteristic	Intervention (n=9)	Control (n=11)	Statistical Test	P
Mean age $\pm$ SD (y)	25.8 $\pm$ 5.4	27.6 $\pm$ 9.5	−0.52	0.61
Sex (male/female)	7/2	6/5	NA	0.37
Mean height $\pm$ SD (cm)	158.8 $\pm$ 7.12	152.0 $\pm$ 10.0	1.7	0.11
Mean weight $\pm$ SD (kg)	78.4 $\pm$ 13.5	61.2 $\pm$ 6.7	3.5	0.01
Mean BMI $\pm$ SD (kg/m ²)*	31.2 $\pm$ 6.0	26.8 $\pm$ 5.2	1.8	0.09
Level of perceived ID			NA	
Mild	2	2		0.63
Moderate or severe	7	9		
Living arrangements				
With parents	8	8	NA	0.38
SSA or independent	1	3		
Employed	4	4	NA	1.00

Abbreviations: BMI, body mass index; ID, intellectual disability; NA, not applicable; SSA, shared supported accommodation.

*Referent BMI is 18.5–24.9 kg/m², overweight is 25–29.9 kg/m², obese is ≥ 30 kg/m².³⁰

No serious adverse events for the intervention were noted. Four participants complained of mild muscle soreness as a result of training, most reports occurring in the early weeks of training, and recovered spontaneously. No other adverse events were recorded.

Over the course of the training program, the intervention group increased the amount of weight lifted during training in the 6 exercises by at least 90% of the initial training resistance. To assess the success of assessor masking, assessors were asked to guess whether a participant had been allocated to the intervention or the control group. Assessors correctly guessed group allocation 56.8% of the time (Fisher exact test, $P=.74$).

Effect of the Intervention

The intervention group had a statistically significant improvement in upper-limb muscle endurance compared with the control group (mean difference in the number of repetitions of the chest press at 50% of 1-RM, 16.7; 95% CI, 7.1–26.2; $P<.01$). There were also trends toward improvement in upper-limb muscle strength (mean difference in chest press 1-RM, 8.6kg; 95% CI –1.3 to 18.5kg; $P=.08$) and upper-limb function (mean difference in time to complete the grocery shelving task, –20.3s; 95% CI, –45.7 to 5.2s; $P=.11$) that favored the intervention group (table 2). There were no significant differences between the groups for lower-limb muscle strength, lower-limb muscle endurance, or lower-limb physical function (see table 2).

DISCUSSION

Our main finding in this study was that upper-limb muscle performance improved in adults with DS after a 10-week progressive resistance exercise program. There was a significant increase in chest press endurance and also a trend toward an increase in upper-limb strength as measured by a 1-RM chest press and upper-limb functional activity as measured by a grocery shelving task. The effect sizes observed were moderate to large (.76–.90) and the changes in upper-limb strength carried over to trends to changes in upper-limb physical function tasks suggests these results may be clinically significant. The change in upper-limb endurance may be relevant in these adults, whose employment involves manual work of the upper limbs.

The progressive resistance exercise program implemented for this study was feasible for adults with DS. It might be expected that adults with DS have difficulty taking part in or being motivated to continue with a progressive resistance exercise program. The majority of participants in this trial had a moderate level of intellectual disability as determined by their parents and carers, yet they were all capable of taking part in the program and experienced benefits from doing so despite their intellectual disability. Compliance with the program was excellent, with participants attending 92% of all training sessions. There were also no withdrawals from the study, indicating that a strength training program was an acceptable form of exercise to the participants. The high attendance rates were likely influenced by the support provided by the day programs attended by the participants. This support included providing transport to and from the community gymnasium and this might be an important factor to consider when setting up future programs.

Another positive finding was that the training program appeared to be a safe intervention for people with DS. No major adverse events were reported by the participants, their families, or the fitness trainers involved in the program. Some participants complained of muscle soreness during the initial weeks

Table 2: Mean Score, Mean Difference Within Groups, and Mean (95% CI) Difference Between Groups for All Outcomes for the Intervention Group and the Control Group

Outcome	Score				Difference Within Groups			Difference Between Groups		
	Baseline (week 0)		Postintervention (week 10)		Week 10–Week 0		Week 10–Week 0*		P*	
	Int	Con	Int	Con	Int	Con	Int-Con (95% CI)	Int-Con (95% CI)		Effect Size (95% CI)
Chest press 1-RM (kg)	35.9±15.4	28.0±10.2	44.9±15.2	31.6±13.3	9.0±8.2	3.6±7.1	8.6 (–1.3 to 18.5)	8.6 (–1.3 to 18.5)	.08	0.68 (–0.20 to 1.59)
Leg press 1-RM (kg)	80.8±25.9	70.8±20.0	96.2±31.6	82.2±19.7	15.4±20.7	11.4±12.0	–1.3 (–22.5 to 20.0)	–1.3 (–22.5 to 20.0)	.90	0.23 (–0.65 to 1.12)
Chest press endurance (no. of repetitions)	15.0±4.7	19.0±8.1	25.9±8.3	17.5±9.5	10.9±8.6	–1.6±8.0	16.7 (7.1 to 26.2)	16.7 (7.1 to 26.2)	.002	1.51 (0.46 to 2.44)
Leg press endurance (no. of repetitions)	44.1±25.9	44.5±21.3	46.8±37.1	49.4±27.6	2.7±47.4	4.9±21.2	16.5 (–23.1 to 56.0)	16.5 (–23.1 to 56.0)	.39	–0.06 (–0.94 to 0.82)
Timed up and down stairs test (s)	16.6±5.2	20.2±6.3	14.4±3.4	18.7±6.5	–2.1±2.7	–1.5±4.3	–3.4 (–7.7 to 1.0)	–3.4 (–7.7 to 1.0)	.12	0.16 (–0.73 to 1.04)
Grocery shelving task (s)	85.1±49.1	122.8±84.0	67.5±33.4	110.7±66.4	–17.6±29.0	–12.0±23.2	–20.3 (–45.7 to 5.2)	–20.3 (–45.7 to 5.2)	.11	0.22 (–0.68 to 1.09)

NOTE. Values are mean ± SD or as otherwise indicated.

Abbreviations: Con, control group; Int, intervention group.

*Derived from analysis of covariance with dependent variable on admission and baseline weight as covariates.

of training, but this was to be expected in a group of people who had not previously participated in a strength training program. This finding is consistent with conclusions that strength training appears to be a relatively safe intervention for people with a broad range of health conditions¹⁰; and may help to counter attitudes that health concerns are a reason why adults with DS should not take part in physical activities.²⁶

No changes in the lower-limb muscle performance of adults with DS were found in this study. There might be a number of reasons for this. It should be considered whether the training program was of sufficient intensity, frequency, and duration. The training program completed by the participants adhered to the ACSM¹⁶ guidelines for progressive resistance exercise; that is, a small number of repetitions could be performed before fatigue, sufficient rest was allowed for recovery between exercises and the amount of resistance was progressed as the ability of the participants increased. During the trial participants were closely supervised to ensure that this was the case and the fitness trainers indicated in the logbooks they completed that the program was progressed as it proceeded. Therefore, it would not seem that the results were due to a problem with the training program.

It is possible that previous trials may have overestimated the size of the treatment effect of strength training for adults with DS. Preliminary evidence from a systematic review⁹ suggested that programs designed to improve strength in adults with DS had large positive effects. However, none of the trials included in this review were RCTs; indeed these trials were repeated measures designs with no controlled baseline or control group data, and may have overestimated the benefits from strength training. Strength training may therefore have positive effects in adults with DS but the size of the effect may be smaller than the previous literature suggests.

It is also possible that the adults with DS in the current study did not have the same potential for improving their lower-limb muscle performance as for their upper-limb muscle performance. For example, upper-limb endurance at baseline was much lower (mean, 15 and 19 repetitions for the intervention and control group, respectively) than lower-limb endurance at baseline (means of 44.1 and 44.5 repetitions for the intervention and control group, respectively) suggesting there was much greater capacity for improvement in the upper limbs. This difference between the upper and lower limbs might be explained by adults with DS routinely using the antigravity support muscles to maintain posture during activities of daily living, such as walking and stair climbing, whereas they may use their upper-limb muscles more infrequently.

Another reason for the lack of change in lower-limb muscle performance was that any true changes may have been obscured by measurement variability. However, standardized procedures were used for testing that have previously been shown to be reliable in other adult populations with disability, and these procedures were able to detect changes in upper-limb muscle performance in the current study.

A training program of longer duration and higher frequency might have resulted in changes in the other outcome measures employed in this study because researchers have reported greater gains in strength from training programs involving longer durations and frequency.²⁷⁻²⁹ The relatively short duration of the program (10wk) may not be enough to produce large changes in lower-limb strength. A program of longer duration might be more effective. Because the majority of the participants had a moderate level of intellectual disability, some took several weeks to adapt to the program and to learn how to use the weight equipment, so that overall the number of weeks they were working effectively was less than 10 weeks. Increasing

the frequency of the program from twice a week to 3 times a week might also change the outcome because previous research studies trained adults with DS 3 times a week and reported larger positive effects.^{11,12}

The main strength of this trial was that it was an RCT that assessed the effects of a progressive resistance exercise program that conformed to the training guidelines of the ACSM for adults with DS. It adds to an area of research where to date only 3 previous studies are known to have investigated if strength training programs are beneficial for adults with DS¹¹⁻¹³ and only 2 of these studies have examined stand-alone progressive resistance training programs. A further strength of this trial was that it was an inclusive community-based exercise program and this is important because people with DS often have restricted opportunities to participate in exercise programs taking place in a community setting.⁶ The use of a group-based program where adults with DS exercised together was important because it made exercising into a more social activity,²⁶ and it is more cost effective and time efficient than individual training. Strength training performed in a community setting, as in this trial, may be a feasible recreation option for adults with DS.

Study Limitations

This trial was limited by the relatively small sample size of 20 participants, which required the effects of the intervention to be large in order to detect any changes as a result of the strength training program. The duration and frequency of the program may also have been too short to result in large changes in muscle performance and functional activities. Future trials should investigate if longer duration training programs are indeed more beneficial.

CONCLUSIONS

Progressive resistance training performed in a community gymnasium is a feasible and safe fitness option for people with DS that can lead to improvements in upper-limb muscle performance. Longer training programs may be required to improve leg strength and activity.

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